BULLETIN 288 OCTOBER 1957

Water in the Santa Cruz Valley

GROUND WATER SUPPLIES OF SANTA CRUZ VALLEY OF SOUTHERN ARIZONA BETWEEN RILLITO STATION AND THE INTERNATIONAL BOUNDARY

By

H. C. SCHWALEN AND R. J. SHAW

Cover by Ted DeGrazia

View of Tucson Basin from southwest along Twin Buttes Road at South Boundary at San Xavier Indian Reservation. The point from which this is taken is on a buried pediment. This is on the Sierrita Bajada looking northeast.

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TABLE OF CONTENTS

TABLES

FIGURES

PHOTOGRAPHS

PLATES

In pocket at back of Bulletin:

ACKNOWLEDGMENTS

The authors gratefully acknowledge the cooperation given by the hundreds of property owners who gave access to their wells that this information could be assembled. The well drillers operating in the valley have made their records available so that as complete an understanding of the formations as possible may be had.

The manuscript was read by Mr. Joel Fletcher of the Agricultural Research Service, United States Department of Agriculture; Mr. Milo James of the Soil Conservation Service; Dr. Robert Humphrey of the Agronomy Department, Arizona Agricultural Experiment Station; and Dr. G. E. P. Smith, Irrigation Engineer Emeritus of the Arizona Agricultural Experiment Station. Their suggestions have proved most helpful.

Dr. H. L. Walster, former dean of agriculture at the North Dakota Agricultural College, spent many hours assisting in revision of this material.

FOREWORD

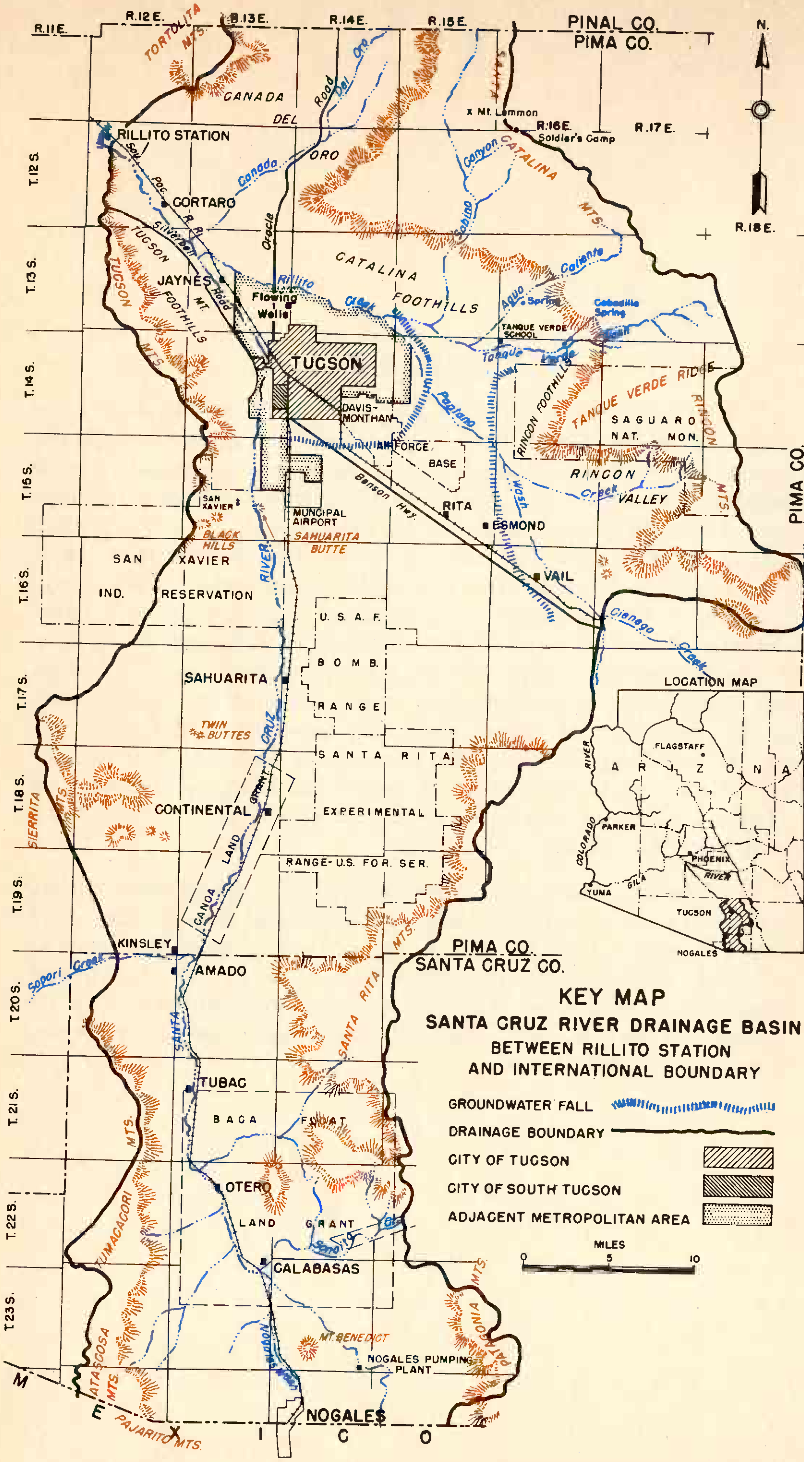
The increasing demand for water in the Tucson area made a study of the effects of pumping upon the ground-water table imperative. Officials of the City of Tucson and Pima County realized that accurate and detailed information of changes in ground-water levels must be available. The cooperation of the City of Tucson and Pima County, who have jointly financed the major portion of the cost of the work, has made possible the collection of data and other field work involved since 1946.

The purpose of this bulletin is to present in permanent form a condensation of the data collected and the results of ground-water studies in this area over a period of years. In particular, it is desired to make readily available to the public the results of an intensive program of measurements of depths of water and changes in water levels in more than 1000 wells during the period 1947-1956, inclusive. The tabulated list of wells with water level data, accompanying charts and maps will supply information concerning ground-water conditions in this basin.

SUMMARY

This bulletin is written to answer the question "Is there water under this piece of land; how deep is it; is the supply adequate and permanent, and is it of good quality?" Some of the other questions often asked the Department of Agricultural Engineering, College of Agriculture of the University of Arizona, Tucson, Arizona, are also answered, such as what changes have occurred in the ground-water table; what caused these changes, and what will happen in the future? There is also a section on the importance and methods of making water level measurements. A short history of the development of water is given to show the reasons for the changes that have taken place and a touch of hydrology is included to give the reader a basis for evaluating a water supply or the possibilities of ground water. The area covered is that portion of the Santa Cruz Valley in Pima and Santa Cruz counties of Arizona east of the Tucson Mountains and west of the Rincon and Santa Rita Mountains. It is the area dominated by the rapidly growing population of metropolitan Tucson.

The data are presented by maps of the ground-water surface and its relation to the land surface, the changes in water level in a nine-year period, 1947 to 1956. A map of the quality of ground water is given. Tables of water measurements made by the Agricultural Engineering Department of the University of Arizona since 1908 are included. In some instances, the 1956 measurements were the extremes, both deepest and shallowest.


KEY MAP
SANTA CRUZ RIVER DRAINAGE BASIN
BETWEEN RILLITO STATION
AND INTERNATIONAL BOUNDARY
GROUNDWATER FALL
DRAINAGE BOUNDARY
CITY OF TUCSON
CITY OF SOUTH TUCSON
ADJACENT METROPOLITAN AREA
MILES
0
5
10
LOCATION MAP
PINAL CO.
PIMA CO.
SANTA CRUZ CO.
COCHISE CO.
RILLITO STATION
CORTARO
JAYNES
TUCSON
DAVIS-MONTHAN AIR FORCE BASE
SAN XAVIER IND. RESERVATION
SAHUARITA
CONTINENTAL
KINSLEY
AMADO
TUBAC
OTERO
CALABASAS
NOGALES
VAIL
ESMOND
RITA
U. S. A. F. BOMB. RANGE
SANTA RITA EXPERIMENTAL RANGE-U.S. FOR. SER.
NOGALES PUMPING PLANT
M E X I C O

GROUND WATER SUPPLIES OF THE SANTA CRUZ VALLEY OF SOUTHERN ARIZONA BETWEEN RILLITO STATION AND THE INTERNATIONAL BOUNDARY

By H. C. Schwalen and R. J. Shaw*

INTRODUCTION

The area under study is the main valley of the Santa Cruz River of Southern Arizona between Rillito, at the north end of the Tucson Mountains, and the International Boundary with Mexico. It includes only those portions of tributary drainage area which lie within the structural trough of the main Santa Cruz Valley. Thus the upper drainage areas of Cienega Creek, Sonoita Creek, Sopori Wash and a few small areas of other tributaries in which no special studies were made are not considered. The area described is shown on the key map, Figure 1.

The drainage area, as shown in Figure 1, directly contributing to the groundwater basin, is marked by the crests of the Tortolita and Santa Catalina Mountains on the north, the Rincon, Santa Rita and Patagonia Mountains on the east, and the Pajarita, Atascosa, Tumacacori, Sierrita and Tucson Mountains on the west. The total drainage area as described contains about 2240 square miles.

The first study of ground water in this valley was initiated by Dr. G. E. P. Smith in 1905 and the results were published in 1910[1]. This was followed by a series of bulletins of the Arizona Agricultural Experiment Station covering the general field of ground-water development and utilization. Summaries of ground-water conditions in the Santa Cruz Valley are included in most of the Arizona Agricultural Experiment Station Annual Reports. Beginning in 1939 the Ground Water Branch of the United States Geological Survey, in cooperation with the Arizona State Land Department, made very comprehensive, widespread studies and the results of these have been made available for our use. Ground-water conditions in the Santa Cruz Valley in 1952 were also summarized in the Report of the Underground Water Commission.[2]

The importance of ground-water supplies to this area cannot be over emphasized. Metropolitan Tucson and the surrounding agricultural area are completely dependent on water stored in the ground. Agriculture is presently the largest user of water. Each irrigated acre requires at least 3 acre-feet per year, or about a mil-

*Agricultural Engineer and Assistant Agricultural Engineer, respectively, Agricultural Experiment Station, University of Arizona.

[1]SMITH, G. E. P., Ground Water Supply and Irrigation in the Rillito Valley, Bul. 64, Arizona Agricultural Experiment Station, 1910.

[2]Underground Water Commission, the Underground Water Resources of Arizona, Report by State of Arizona, Jan. 1, 1953.

lion gallons of water per year. It is estimated that this is the equivalent to seventeen people per capita in the Tucson area. It is estimated that the 210,000 people living in Tucson and its suburbs used about 41,000 acre-feet for domestic use in 1956. If the city continues to grow at its present rate, some water will have to be diverted from agricultural use to meet future municipal needs, or new sources must be found.

Water requirements by the mining industry are principally for the use of milling low-grade ore. At this date, very little water is used in this area for this purpose; although, recent developments near Sahuarita indicate that a significant amount of water may be needed for milling in the future. The consumptive use of water in milling low-grade ore is about 250 gallons per ton of ore.

The possibility of capturing flood waters for recharge is being investigated by this Department and other agencies. Importation of water from the adjacent San Pedro or Avra Valleys is also being considered as a source for future water supplies.

PHYSIOGRAPHY OF THE AREA

The Santa Cruz River has its source in the San Raphael Valley where it drains the east slopes of the Patagonia Mountains, the south slopes of Canelo Hills and part of the west slope of the higher Huachuca Mountains on the east. It flows south across the International Boundary into Mexico, making a 35-mile loop before re-entering Arizona about 6 miles east of Nogales, continuing in a northerly direction to Tucson. It then flows northwest and finally joins the Gila River about 12 miles southwest of Phoenix, 225 miles from its source.

Seldom do flood flows originating in the upper reaches of the Santa Cruz River reach the Gila River and then only when they have been augmented by tributary flows from the lower portion of the drainage area.

Structurally, the Santa Cruz Valley is a typical example of the Basin and Range Province of the Southwestern United States. Northward trending mountain ranges border the broad, flat alluvium-filled valley. (See Figure 1.) The present relief is the result of block faulting with the last uplift of the mountain formations taking place in the late Tertiary or early Quaternary period. To a minor extent volcanic extrusions of basalt also occurred in the late Tertiary or early Quaternary period.[3] Typical examples are "A" Mountain and Tumamoc Hill west of Tucson, and Sahuarita Butte and the Black Hills, near the San Xavier Mission. Contemporaneous with and following the period of mountain building, there was a long period of erosion during which vast quantities of alluvium were deposited in the valley.

At the time of maximum filling, the floor of the Santa Cruz Valley presented comparatively smooth slopes extending from the base of the mountains to the valley trough. Coalescence of the numerous outwash fans at the base of the mountains has resulted in the long slope, typical of the Southwestern desert valleys and referred to as bajadas in this region. There was probably, during the period of valley filling, a continuous drainage pattern through the center of the valley which was then at higher elevation than the present trough.

Later, due either to climatic changes or crustal movements, there followed several periods of erosion during which the upper bajada slopes were deeply dissected by

[3]BROWN, W. Horatio, Tucson Mountains, An Arizona Basin Range Type, Bul. of Geol. Sci. of Amer., Vol. 50, p. 753, 1939.

lateral washes. Evidence of entrenchment by the main stream channel at a much higher level and of tributary channels is seen in the erosional scarf visible in many places on the valley slope and by the benches left in tributary valleys. In places, the remnants of at least two of these erosional scarves may be observed in the valley slopes.

The last distinct period of erosion or entrenchment was in Recent* geologic time. The present bottom lands and flood plains represent the height to which these inner valleys were refilled during the subsequent period of deposition.

The inner valley or bottom land is, in general, bordered by bluffs on both sides. These bluffs vary in height from a maximum of over 100 feet south of Tubac to approximately 50 feet near Continental, about 25 feet near Tucson and gradually become smaller until they disappear near Rillito Station.

The physiography of the typical Southwestern semi-desert valley has been described in detail by Smith.[4] Prior to 1890, the Santa Cruz and its principal tributaries flowed in comparatively narrow, shallow swales and flood water spread out over the bottom land, which in places, is from a mile to one and one-half miles in width. Since then the river has entrenched itself in the floor of the inner valley to depths of between 5 and 25 feet and has developed a continuous channel through the drainage basin. (Figure 2.) Deepest entrenchment occurs between Continental and Tucson and except in a few locations, the channel section is now large enough to carry the normal flood peaks. In its present stage, channel changes and widening by under cutting of vertical banks on curves occur during every flood period.

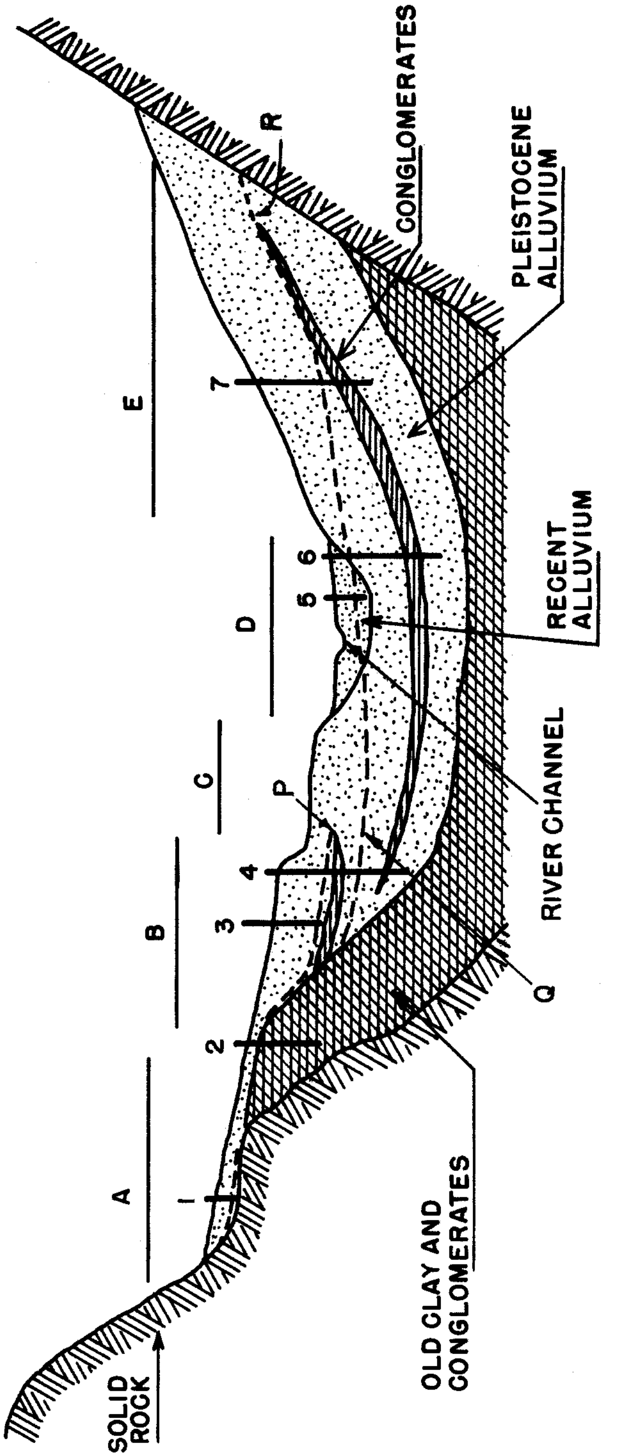
The Santa Cruz River has been moved west of the axis of the valley in the northern half of the basin, presumably as the result of the relatively large quantity of detrital outwash material brought in from the greater areas and higher mountains on the east. Forming the eastern drainage divide are the Santa Catalina and Rincon Mountains, which rise to an elevation of more than 8,000 feet and south of Cienega Creek is the northern section of the Santa Rita Mountains, rising to more than 6,000 feet. While opposite them on the west and northwest are the comparatively low Tucson and Tortolita Mountains, which with the exception of a few isolated peaks, are only between 3,000 and 4,000 feet in elevation.

Farther to the south, the west edge of the drainage basin is marked by the more or less isolated Sierrita and the Tumacacori Mountains, with their higher peaks reaching elevations of about 6,000 feet. Opposite this group of mountains and forming the eastern drainage divide are the Santa Rita Mountains, which extend south to Sonoita Creek.

The southernmost portion of the drainage basin, between Calabasas and the Mexican Boundary, has the Atascosa and Pajarita Mountains forming a western boundary with mountain peaks at 5,000 to 6,000 feet. The Patagonia Mountains, located between 20 and 25 miles to the east form an eastern boundary with mountain peaks at 6,000 to 7,000 feet elevation. Almost in the center of this portion of the drainage basin is located Mt. Bene-

*Geologists generally use the term Recent to cover the interval of the last 20,000 to 50,000 years since the passage of the last glacial stage and during which the aspect of the earth's surface has changed but little and the animal and plant life differs but little from that at the end of the glacial epoch.

[4]SMITH, G. E. P., The Physiography of Arizona Valleys and the Occurrence of Groundwater, Tech. Bul. 77, Arizona Agricultural Experiment Station, 1938.



CROSS SECTION OF TYPICAL ARIZONA VALLEY

- - - - - - - WATER TABLE

FIGURE 2

CROSS SECTION OF TYPICAL ARIZONA VALLEY

Figure 2

Typical cross section of valley shows A, Buried rock and conglomerate pediment. B, Deep alluvial fill with perched table supported by conglomerate shows two water tables, P and Q. The upper table is fed by water from the side which cannot drain through conglomerate to the normal table. Lowering of the normal table has extended under the conglomerate leaving a zone of areation. C, Deep alluvium under second bench. D, Bottom land, geologically the youngest formation. E, Bajada slope.

Well 1 — Shallow well on rock pediment. This well can be expected to produce a small amount of water rather consistently only varying as the rainfall changes.

Well 2 — A moderately deep well drilled into the older conglomerates without encountering water in the veneer of recent alluvium. This will be a dry hole or similar to the well shown in Figure 3, page 16.

Well 3 — Drilled only to perched table, a small producer, but the water table will not fluctuate with demands in the valley.

Well 4 — A deep well penetrating the perched table into the main body of water in the valley. This well will "underdrain" if perforated in the perched table. See Appendix on well measuring.

Well 5 — Older irrigation well drilled to "Recent" bottom land formation only. Considerable production has been lost, since the water table lowered from its original elevation controlled by depth of river channel.

Well 6 — A deeper irrigation well drilled into the older alluvium even to the Pleistocene clays. This well may have more or less artesian pressure from the water moving down the side of the valley which becomes trapped under the conglomerates at point R.

Well 7 — Drilled into a bajada and through the conglomerate layer. This well may or may not show some sub-artesian pressure. In some instances, the water level may be more than 700 feet in locations of this type.

dict, an intrusive-igneous rock mass,[5] and extending south from it are found the bedded tuffs and aglomerates upon which most of the City of Nogales is located. These rock masses rise to an elevation of over 4,500 feet and form, more or less, an island in the middle of the valley with the Santa Cruz River channel on the east and Nogales Wash on the west.

VEGETATION

Vegetation within the drainage basin consists of typical desert cover at the lower elevations, grasslands and mesquite on the upper valley slopes, and pine and Douglas fir forests on the highest mountain tops. Vegetative types and density are closely correlated with temperature and precipitation in the area. Both of these factors are directly related to elevation. The predominant members of each vegetative type have been listed on this basis by Nichol[6] as shown in Table 1.

Table 1. – CORRELATION OF PREDOMINANT VEGETATIVE TYPES WITH ELEVATION IN THE SANTA CRUZ DRAINAGE AREA*

Vegetative Types	Elevation above Sea level (ft.)
Southern desert shrub, palo verde, cacti bursage, creosote bush, grass, with mesquite along stream channels	2,000 - 3,500
Desert grassland, mesquite	3,500 - 4,500
Chaparral, scrub oak, Mexican blue oak manzanita	4,500 - 5,500
Pinion, juniper	5,000 - 7,000
Ponderosa pine, Douglas fir	6,500 - to top

WATER SUPPLY

The ground-water reservoir of the Santa Cruz Valley for all practical purposes is dependent for its water supply upon the precipitation within its immediate drainage basin. An exception to this is that part of the surface flows entering the basin from Cienega Creek, Sonoita Creek and the Santa Cruz River in Mexico which is retained in the basin. The amount of water entering the ground-water basin as underflow from these sources is estimated to be not more than a few thousand acre-feet per year, nor does much more water leave the valley through the narrows at Rillito.

Precipitation

Precipitation occurs in two rather distinct seasons of the year, a summer rainy season beginning in the latter part of June and extending through September, and a winter rainy season from November through March. The summer rains occur as thunder storms and are of short duration, high intensity and small areal extent, and usually occur in the late afternoon or evening. The shorter summer rainy season provides about one-half of the average annual rainfall at Tucson and about 60 per cent at Nogales. During the summer season, extremely high specific humidity at high altitude (above 10,000

[5]SCHRADER, Frank C., Mineral Deposits of the Santa Rita and Patagonia Mountains, Arizona, Bul. 582, Department of Interior U. S. Geological Survey, 1915.

[6]NICHOL, A. A., The Natural Vegetation of Arizona, Revision of Technical Bulletin No. 68, Arizona Agricultural Experiment Station, 1952.

*For a more complete discussion of this subject the reader is referred to Publication No. 217 of the Carnegie Institution of Washington, the Vegetation of a Desert Mountain Range as conditioned by Climatic Factors, by Forrest Shreve, and University of Arizona Technical Bulletin No. 68, The Natural Vegetation of Arizona, by A. A. Nichol.

feet) is maintained over this entire region by anti-cyclonic circulation bringing in moist air from the Gulf of Mexico and the Pacific Ocean, south of Mexico.

The winter rainfall is associated with the cyclonic storms from the West in their passage across the continent. Many storms which originate in the Pacific Northwest take a southeasterly course and some swing far enough south to cross Arizona. Others may have their origin in the Pacific Ocean and come in from the West or Southwest. The individual storms may be of several days duration and of wide extent with rainfall being recorded at practically every station in the state. The rains are usually of low and steady intensity, although not continuous throughout the entire storm period. This type of precipitation is conducive to storage of large amounts of surface soil moisture which does not reach the ground-water table. At the higher elevations in the form of snow, it is the source of spring runoff, an important source of recharge to the ground-water reservoir.

Rainfall within the drainage basin is most closely related to elevation and as a result, varies widely. The average annual rainfall in the trough of the valley varies from a minimum of about 10 inches at Rillito (elev. 2,060 feet) to about 16 inches at Nogales (elev. 3,800 feet). At the other extreme, the average annual rainfall at Soldier Camp (elev. 7,875 feet) in the Santa Catalina Mountains is over 34 inches. Schwalen[7] has prepared a rainfall map for the entire Santa Cruz drainage area above Rillito for the period, 1913-1941. Using this map as a basis and adjusting to the 1913-1956 period, inclusive, the average precipitation upon the area directly contributing to the ground-water basin is estimated to be about 1,800,000 acre-feet.

The annual rainfall at any individual rain-gage station is subject to wide variation from the mean of a long-term record, with a minimum of less than 50 percent and a maximum of over 200 percent of the mean. There has been as much as 50 percent variation in the seasonal catch, especially during the summer months, in gages located as little as four miles apart.

Runoff

Surface runoff in stream channels is the most important source of recharge to the ground-water reservoir in this area. The comparatively silt-free runoff from melting snow in early spring provides the opportunity for maximum recharge by seepage into the stream bed. The flows are more uniform than summer floods and may be continuous over a period of several months at a season of the year when recharge is most effective with minimum losses by evaporation or transpiration.

The short, intense summer storms of small areal extent result in short-lived flows, which may locally cause erosion in the side washes and on the valley slopes, but are relatively ineffective as a source of recharge to the ground water. The coincidence of several of these storms in the same general area and extending over a period of several weeks has resulted in flood flows of considerable size and duration. They are the exception rather than the general rule. However, the summer flows in 1954 and 1955 in the Upper Santa Cruz were excellent examples of effective recharge which may result from summer runoff of this type.

It is unfortunate that stream-flow records are available at but few places on the larger streams and estimates of contributing flow from smaller tributaries are largely guess work. The value of quanti-

[7]SCHWALEN, Harold C., Rainfall and Runoff in the Upper Santa Cruz Drainage Basin, Tech. Bul. No. 95, Arizona Agricultural Experiment Station, 1942, Pl. I.

tative estimates of seepage losses from flood flows based upon stream-flow records is thus largely dependent upon the judgment and experience of the person making the study. Stream-flow records for those gaging stations in the area, for which the period of records are of sufficient length to make the average annual discharges representative, are given in Table 2.

Table 2.—AVERAGE ANNUAL DISCHARGE AT STREAM GAGING STATIONS IN THE UPPER SANTA CRUZ GROUND-WATER BASIN*

Period of Record	Name of Stream	Location	Drainage Area	Average Annual Discharge
Years			Sq. Mi.	Ac.-Ft.
1931-33 1935-54	Santa Cruz River	5½ miles E. of Nogales & ¾ mile N. of Mexican Border	542	13,030
1931-33 1935-54	Sonoita Creek	5 miles W. of Patagonia	210	4,760
1906-54	Santa Cruz River	On W. Congress St., Tucson	2,190	15,560
1945-54	Tucson Arroyo	On S. Vine Ave., Tucson	21.5	580
1905-11 1933-54	Sabino Canyon	13 miles N.E. of Tucson at mouth of canyon	35	8,540
1909-54	Rillito Creek	5 miles N. of Tucson and 4¾ miles above mouth	916	12,950

*Records from U. S. Geological Survey, Surface Water Branch, Douglas D. Lewis, District Engineer, Federal Building, Tucson, Arizona.

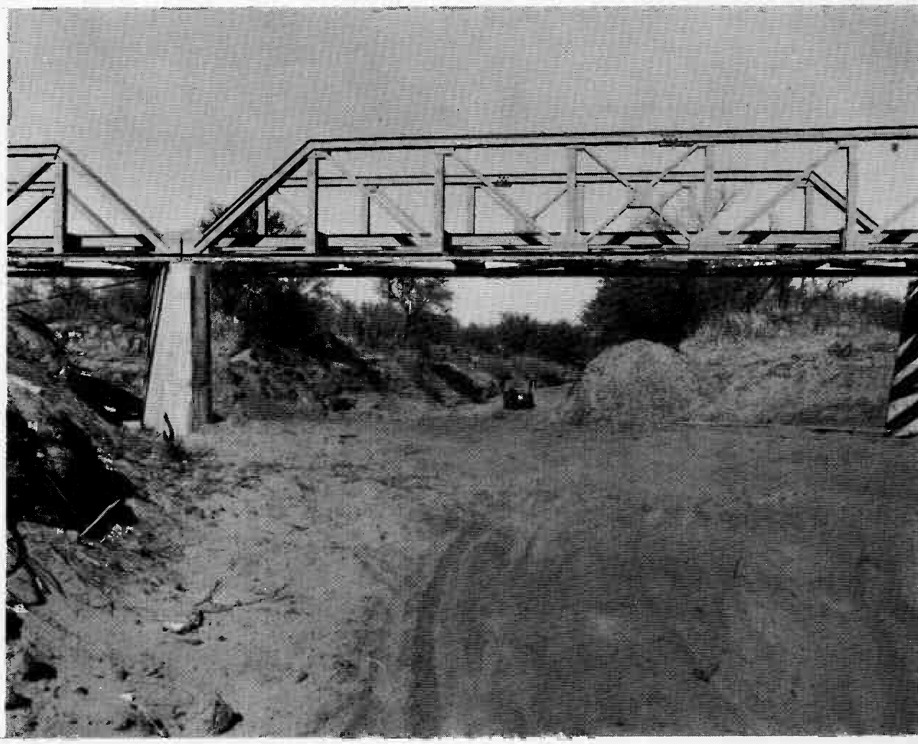
The unit runoff from small areas will vary widely, depending on the terrain, soil conditions and position in the valley. Table 3 gives the total runoff and flow in acre-feet per square mile for two mountain watersheds, and one near the center of the valley. Sabino Creek drains much of the south side of the Santa Catalina Mountains. Rincon Creek has the same type of topography, in the Rincon Mountains. Tucson Arroyo is the area between the City and Davis Monthan Air Base.

Table 3.—RUNOFF FROM SMALL DRAINAGE AREAS IN THE TUCSON BASIN. MEASUREMENTS BY SURFACE WATERS DIVISION OF UNITED STATES GEOLOGICAL SURVEY

Calendar Year	Sabino Creek		Rincon Creek		Tucson Arroyo	
	Total	Per Square Mile	Total	Per Square Mile	Total	Per Square Mile
1953	1,740 a.f.	49 a.f.	591 a.f.	13 a.f.	732 a.f.	40* a.f.
1954	12,330	347	2,770	62	1,040	65
1955	5,690	160	4,780	107	992	62

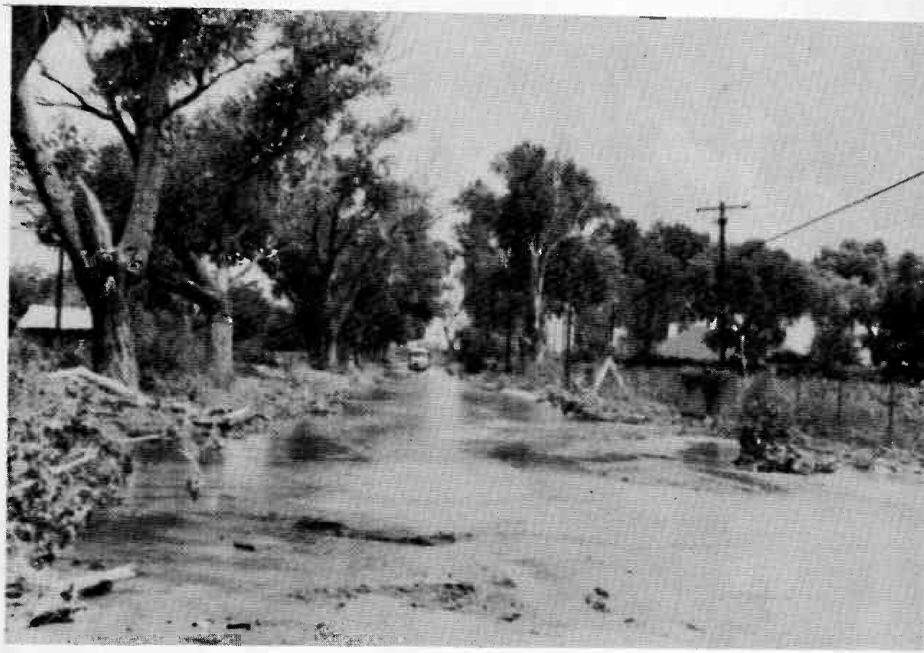
a.f. — acre feet

*The area of the Tucson Arroyo was decreased between 1953 and 1954 by diverting the flow from 2.2 square miles to another watershed.



Photograph 1

Bed of Santa Cruz River 3 miles north of Sahuarita. The channel here is too narrow for much recharge. Bridge is on new road to mines in rock pediment of Sierrita Mountains. Photo by John Burnham.



PHOTOGRAPH 2

Aftermath of severe summer storm. This type of storm gives recharge by seepage into streambed. Almost none of the water shown here will penetrate below the root zone.

The Santa Cruz River near Nogales, Sonoita Creek, Cienega Creek and Sopori Wash constitute the principal sources of surface inflow into the basin. The flow of the latter two streams is not measured. Tucson Arroyo, Sabino Canyon and Rincon Creek are tributary streams within the basin for which discharge records are available. The combined flow of the Santa Cruz River at Tucson and Rillito Creek near Tucson approximates the surface flow leaving the drainage basin at Rillito. Table 2 shows the average combined flow of the two streams is about 28,500 acre-feet per year.

Runoff-Rainfall Relations

In general the ratio of runoff to rainfall per unit of area is less from a large area than from a small area of similar topography and rainfall. The average values expressing this relationship are surprisingly low, even for drainage basins in the arid Southwest.

Earlier studies indicate that for the entire Santa Cruz drainage area of 2,190 square miles above Tucson, the average runoff for the 19-year period 1923-1941 was only 0.6 percent of the rainfall.[8] Comparable figures for Rillito Creek near Tucson with a drainage area of 916 square miles were 1.0 percent. Maximum and minimum values for individual years for the Santa Cruz were 1.4 and 0.1 percent, and for Rillito Creek 3.3 and 0.2 percent, respectively.

In contrast with these figures is the reported spring runoff of 36,000 acre-feet from Sabino Canyon in 1905, equivalent to an average runoff of 19 inches from 35 square miles of drainage area, or about 50 percent of the estimated rainfall. Records indicate that runoff from a heavy rainfall in a general storm extending over a period of several days has equalled 7 percent of the rainfall on the Santa Cruz drainage and has been considerably greater on the Rillito drainage. However, in the aggregate the surface runoff leaving the drainage basin at Rillito accounts for an extremely small percentage of the total water supply in the form of rainfall.

Ground-Water Recharge

It is evident from the effects of pumping draft upon the Santa Cruz groundwater reservoir that only a small percentage of the total average rainfall of 1,800,000 acre-feet which falls upon the directly contributing drainage area is recharged to the ground water. By far the greater part of it is immediately lost by evaporation from the soil and vegetative surfaces or subsequently by evapo-transpiration. That part of the precipitation which finally becomes a part of the main body of ground water comes from the following immediate sources: (1) direct infiltration from rainfall; (2) seepage from stream channels; (3) seepage from irrigated lands; (4) sewage effluent; and (5) ground-water movement into the basin as underflow.

Direct recharge to the water table from precipitation is of minor importance. An exceptional rain of 2 inches upon the normally dry desert valley floor and slopes is sufficient only to wet the soil to a depth of a foot or two. At the end of a long rainy period and then, only under the most favorable conditions for infiltration, will the soil be wet to a depth of more than a few feet. The results to be expected from the average rain should be compared with irrigation practice where the farmer requires a depth of 6 inches of water to wet a cultivated dry soil to a depth of 4 to 6 feet prior to planting. Rarely does rainfall upon the valley floor penetrate to a depth below the root zone of native

[8]SCHWALEN, Harold C., Rainfall and Runoff in the Upper Santa Cruz Drainage Basin, Tech. Bul. No. 95, Arizona Agricultural Experiment Station, 1942, p. 470.

vegetation or wet the soil beyond the depth from which it will be lost by surface evaporation.

Significant, but limited, recharge from rainfall does occur through the fractures and joints in the rocks at the base of the mountains and also in some areas of coarse, open ditrital outwash adjacent to the mountain base. The generally impermeable character of the mountain rock formations precludes any appreciable movement of ground water from the mountain areas down to the ground-water reservoir.

Seepage from stream channels during periods of flow is the major source of ground-water recharge in this area. The wide, sandy portions of the stream channels of the Santa Cruz River and Rillito Creek, with their larger tributaries provide the most effective means of the infiltration of flood waters direct to the ground-water table. The recharge from smaller washes and arroyos is limited by the infrequency and short duration of their flow and in some cases, by impervious formations immediately below a comparatively shallow, sandy stream bed. Phreatophytes along small streams with shallow, sandy beds will consume the seepage before it can percolate to the ground-water table.

Seepage or deep percolation losses from irrigated land and ditches is actually just circulation of the ground water, but it is a source of return flow in the immediate area of use. Often it may amount to 25 percent of the total pumpage, and in particularly porous soils, may even be more. It is thus a factor which must be considered in any ground-water inventory.

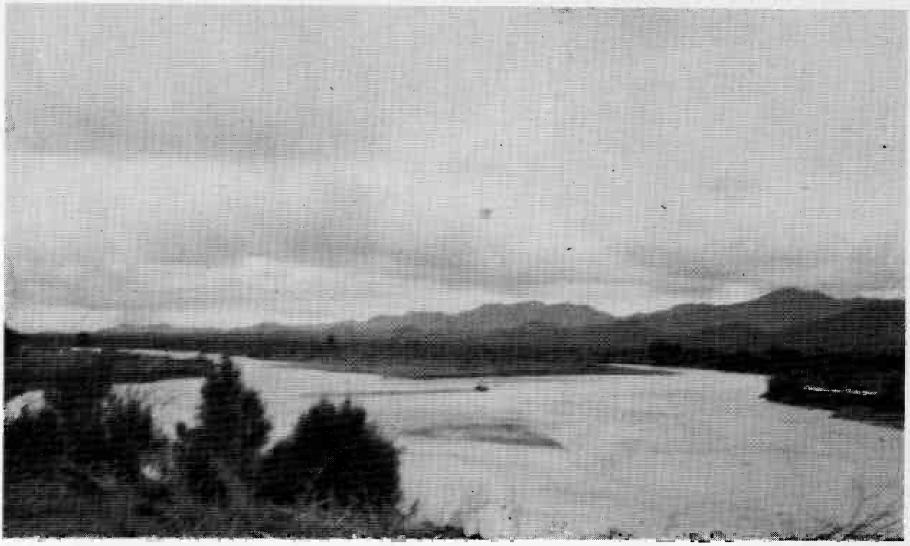
The portion of the sewage effluent which is returned to the ground water is somewhat comparable to seepage losses from irrigation. Both Tucson and Nogales utilize part of the sewage effluent for irrigation. The seepage from this is recharged to the ground water. This seepage has been purified by filtration through the ground, so that it no longer has any characteristics of sewage.

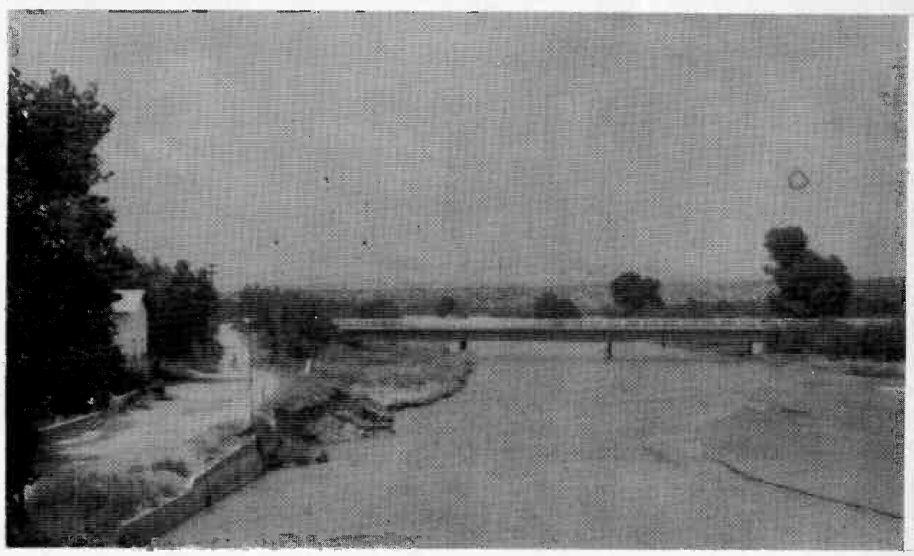
Ground-water inflow into the main Santa Cruz basin as underflow of the Santa Cruz River at the Mexican Boundary and from the tributary streams – Sonoita Creek, Sopori Wash and Cienega Creek – is believed to be small. All these streams enter the basin in places where the underflow is constricted to narrow ground-water channels of small cross-sectional area. The resulting aggregate underflow is estimated to be of only a few thousand acre-feet per year.

THE GROUND-WATER BASIN

The ground-water basin of the Upper Santa Cruz Valley is limited to the alluvium-filled part of the valley between the north end of the Tucson Mountains and the junction of the Santa Cruz River and Nogales Wash, together with the extension of the narrow inner valleys of these two streams to the International Boundary. The outline of the basin is indicated by the edges of the mountains or the buried rock pediments. (Plate I) The effective portion of the basin from the standpoint of ground-water storage or movement is confined to that part of the valley fill which is below the fluctuating water table and is sufficiently permeable to permit the economic development of ground water.

The Recent fill occupies an inner valley of the Santa Cruz and tributary streams from depths of about 50 feet near Calabasas to depths of possibly 250 feet at Rillito. It forms the stream bed or flood plain of all water courses and, in places, blankets the older alluvium on the valley slopes or bench lands. The Recent unconsolidated strata of sand, gravel and boulders underlying the flood plains were the





PHOTOGRAPH 3

Santa Cruz River in flood near Nogales showing wide sandy streambed, the best source of recharge to the ground-water table.

PHOTOGRAPH 4

Irrigation ditch in sandy soil, an excellent chance for seepage loss or allowing pumped water to recirculate to the ground-water table.

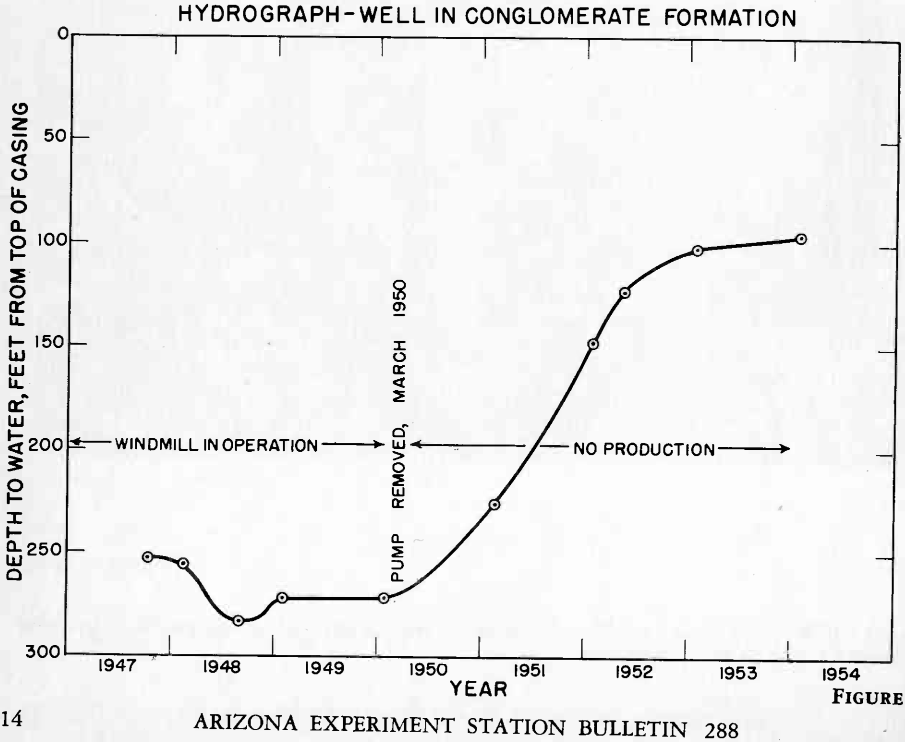


FIGURE 3

first to be recognized as excellent sources of ground water. These deposits provided wells of sufficient capacity for irrigation at depths of from 30 to 150 feet. With lowering water levels, much of the Recent fill has been unwatered and in such areas, water supplies must now be developed from the underlying older alluvium often with reduced yields. Occasionally a good aquifer is found in the older material.

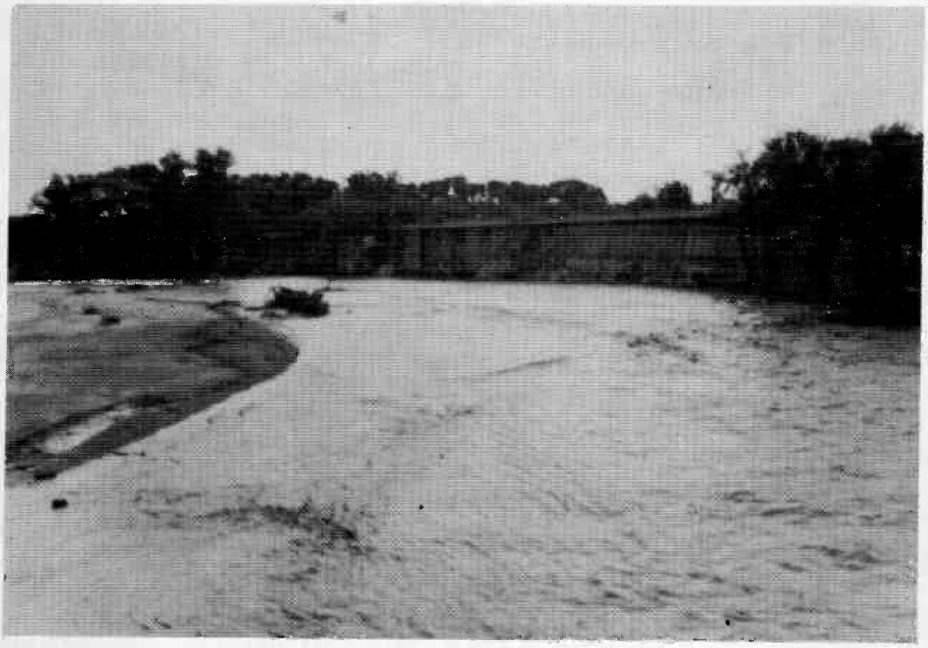
Since the later Tertiary time there have been a few volcanic extrusions. The most recent of which, in the vicinity of San Xavier Mission and "A" Mountain, are basaltic in character. They overlay, in part, the alluvial valley fill, but probably altered it somewhat by heat and compression. This alteration has created ground-water barriers or dams which force the water table closer to the surface.

The older Quaternary alluvium consists of locally stratified lenses of boulders, gravel, sand, silt and clays, with cemented zones and caliche. The coarser detrital outwash material is found nearer the mountains, but it is apparent that stream channels at times extended well into the center of the valley, as evidenced by the stratum of coarse sand, gravel and boulders up to 12 inches in diameter, encountered at depths between 111 and 128 feet in two wells on the University campus at a distance of eight miles from the base of the Santa Catalina Mountains. The finer-grained sediments, clays, silts and fine sands with more cementation appear to predominate in this area with increased depth.

There is wide variation in the permeability of the older alluvium. In some areas decomposition and disintegration of the rock particles and accompanying cementation has resulted in extremely tight formations in which wells of only very small capacity are found. In some locations, possibly in the ancient buried stream deposits, the formations resemble those found in the Recent alluvium. In logs of wells it is not often possible to distinguish between the Quaternary deposits and the underlying Tertiary, except for the characteristic red bed.

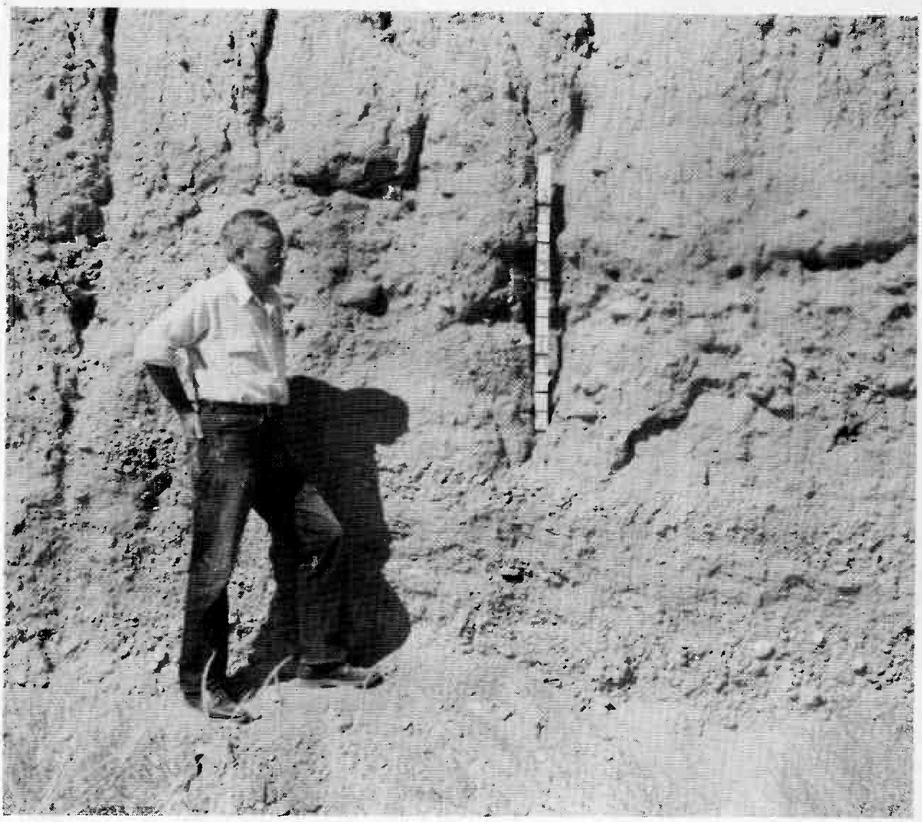
The exposed red beds between the base of the Santa Catalina Mountains and Rillito Creek have been correlated with the Pantano formation, Tertiary, by Moore, Tolman and other geologists.[9] Close to the mountain they are tilted with minor faulting in the stratified beds of more or less indurated conglomerates, sands and clays and occasional thin interbedding of gypsum. Farther from the mountain the beds where exposed, as well as samples from drilling, are fine grained sands, silt or clay. Wells have been drilled in this formation to depths of 500 and 600 feet without encountering a water supply sufficient for domestic purposes. The thickness of the Pantano formation and the areal extent of the formation underlying the other parts of the basin are unknown. A well drilled in Section 25, Township 13 S., Range 15 E. was reported to still be in the red formation at a depth of 900 feet, as was a well at the Tanque Verde School. The specific capacity of wells drilled in this area is very small, often negligible. An example of fluctuation of the water level in a well in a small section of the Pantano formation near the Tucson Mountains, is given in a hydrograph. (See Figure 4.) This shows the perpetual drawdown caused by a windmill pump and the exceedingly slow recovery for several years after the pump was removed. Often the limited water supply encountered in red formations is of poor quality being both hard and salty. This is not universally true, but it

[9]MOORE, B. M., Tolman, C. F., Butler, B. S., Heron, R. M., Geology of the Tucson Quadrange, U. S. G. S. open file report, Text and map on file at Arizona Bureau of Mines, Tucson, Arizona.



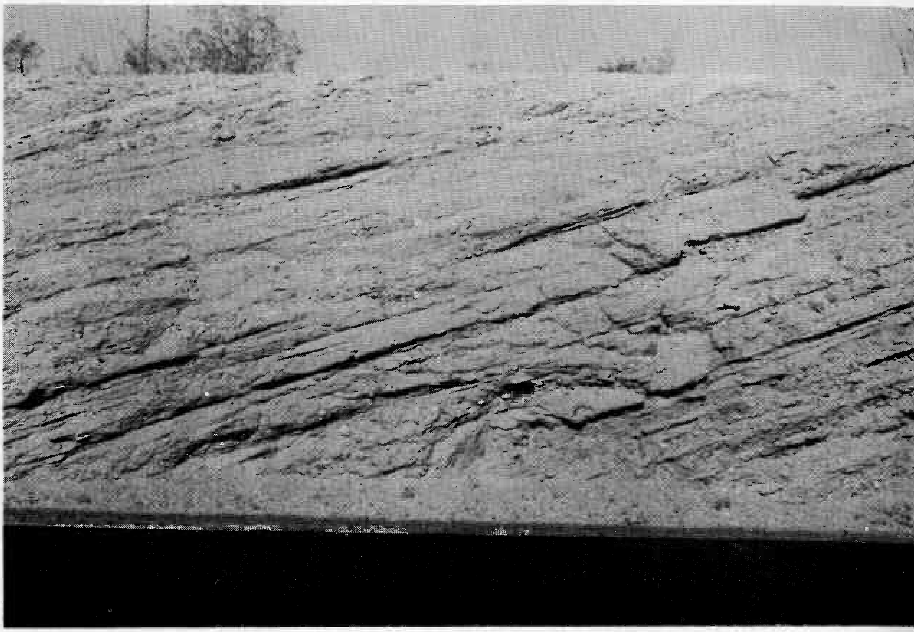
PHOTOGRAPH 5

Flow in Santa Cruz River near San Xavier Mission. This type of flow, if sustained, contributes appreciably to the recharge of the ground water. Note under cutting of bank has cut into dugway of old road crossing on right.



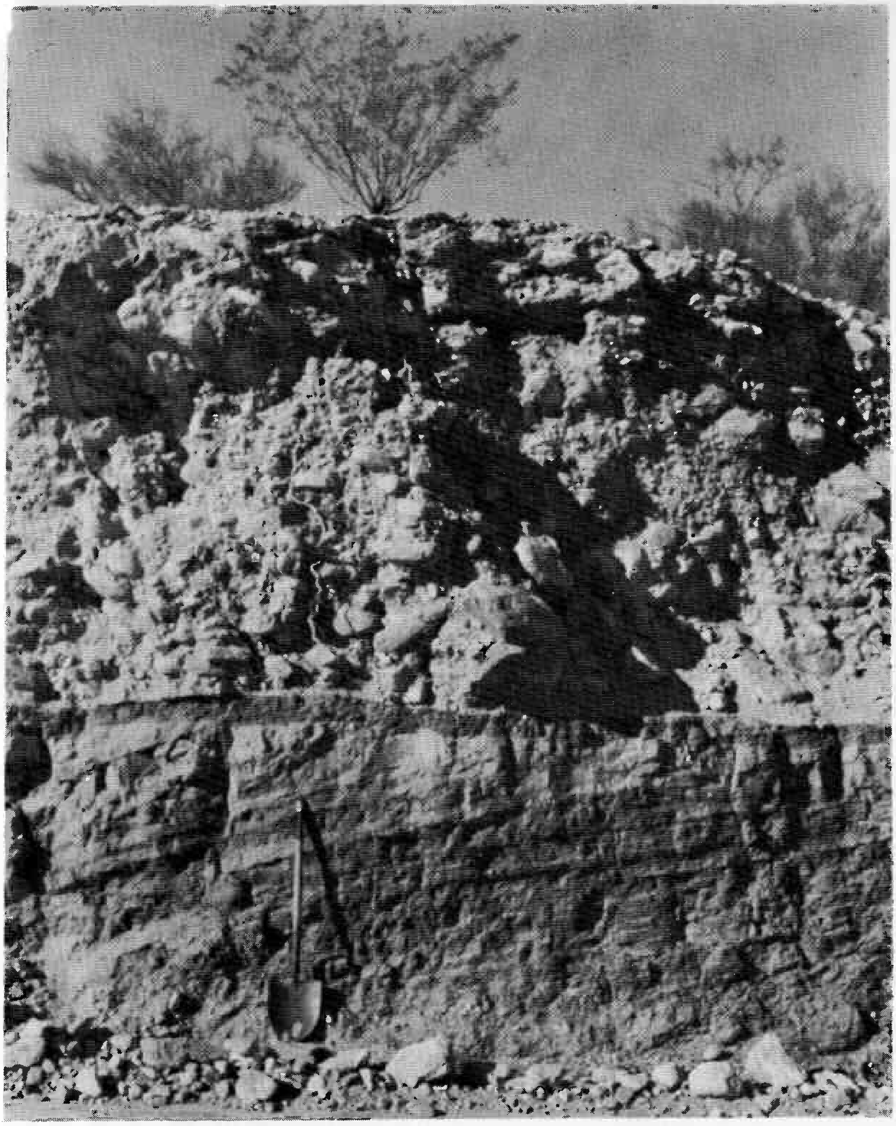
Photograph 6

Photo of cut along Nogales Highway shows stratification of clays, silts, sands and gravel. This would have been reported as clay, sand and gravel in a well log. Yet, it would make an excellent aquifer. This would be classed as Older Quaternary Alluvium. Photo by Walker Bryan.



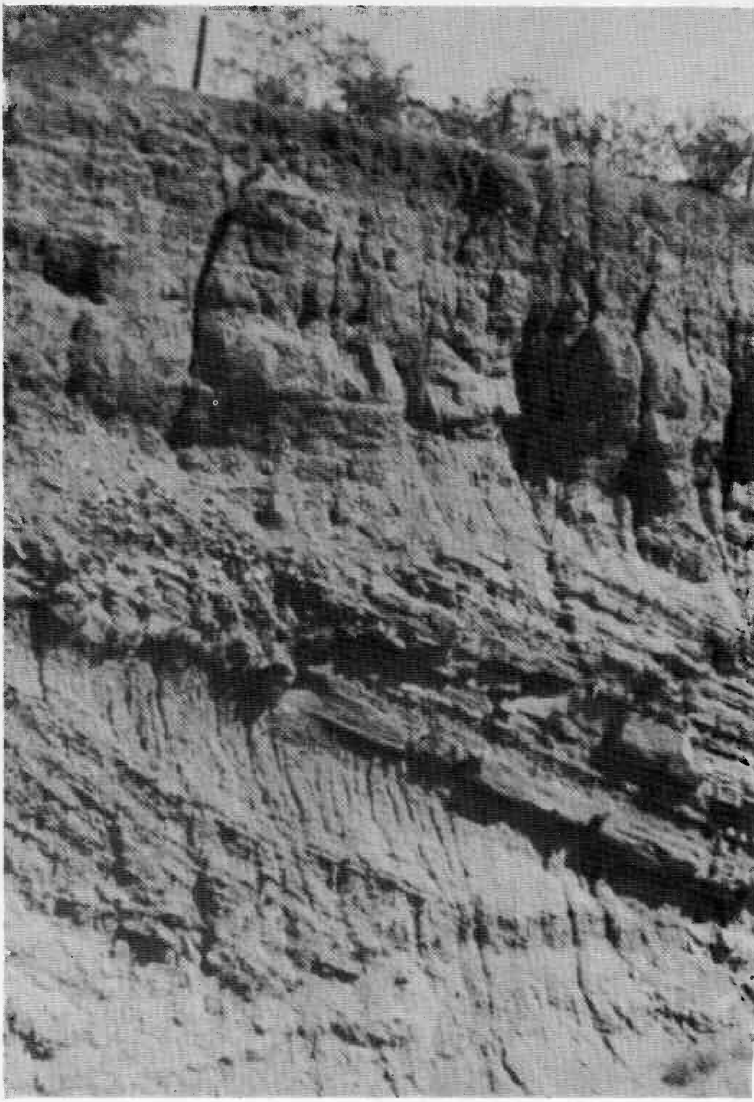
PHOTOGRAPH 7

Photograph of tilted Pantano Beds exposed in a cut on Mount Lemmon Highway about two miles from base of Catalina Mountains. The Pantano formation is characterized by a reddish to chocolate color. It is usually tilted, a very poor or barren source of ground water. Photo by John Burnham.



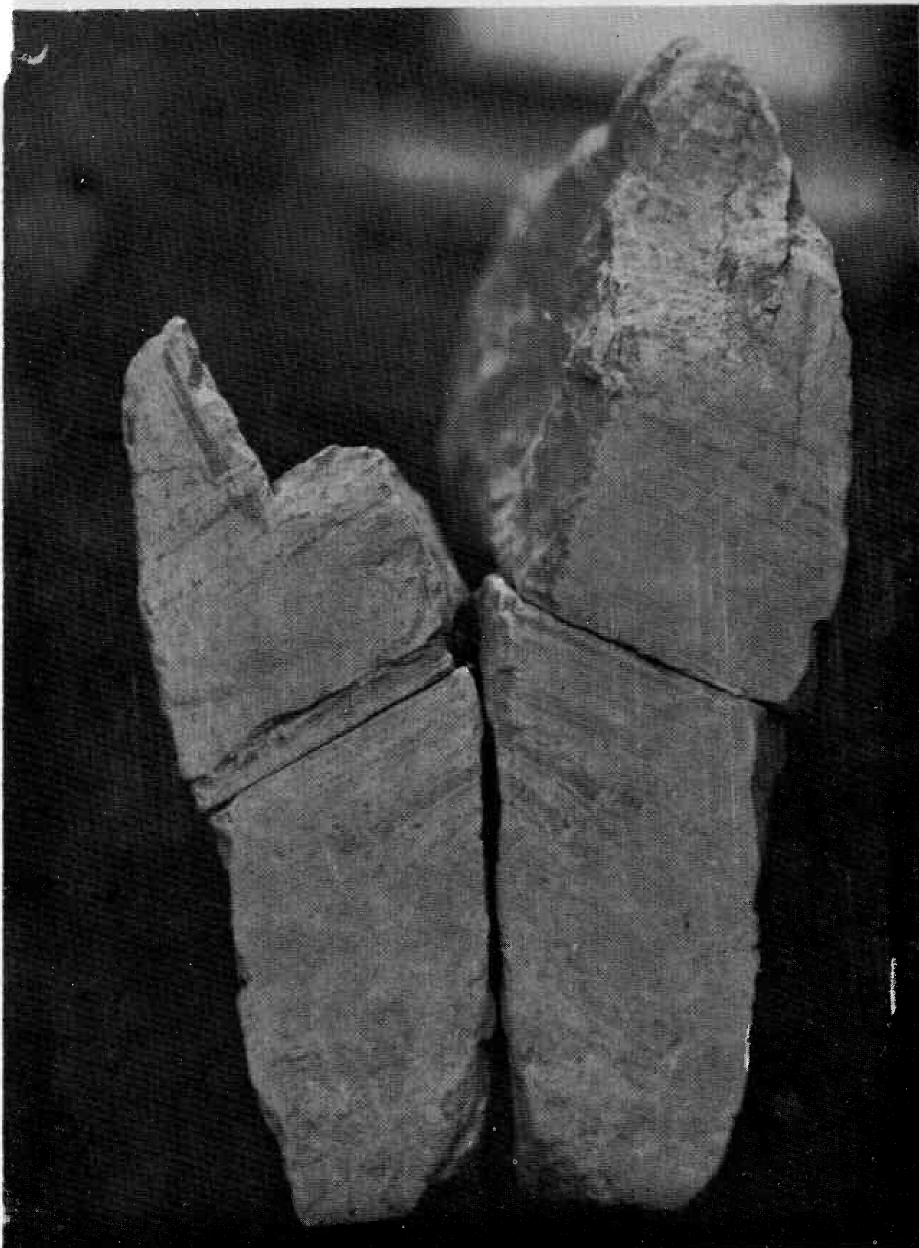
PHOTOGRAPH 8

Photograph of layer of Recent Alluvium, Catalina outwash material overlying tilted Pantano, Pliocene formation. Photo by John Burnham.



PHOTOGRAPH 9

Pantano formation, Tertiary or Pliocene overlain with Pleistocene or Recent Valley Fill. Note tilt to bedding planes of Pantano.



PHOTOGRAPH 10

Photo of cut piece of clay from 810 foot depth in Tucson Gas, Electric Light and Power Company well in Section 3, Township 15 South, Range 14 East. These are the two sides of the cut section. We do not know which end was up in the well, nor which side of the well it came from. From the angle between bedding planes and the long dimension, it is evident the formation was tilted in some direction. This shows the value of undisturbed samples in analyzing the type of formation being encountered. Photo by Walker Bryan.

is advisable to have a sample of the water from new wells analyzed before making plans for its use.

It is probable that the greater part of the central portion of the Santa Cruz Valley is underlain with Tertiary deposits similar in character to the Pantano formation. A well recently completed in Section 3, T. 15 S., R. 14 E., by the Tucson Gas, Electric Light and Power Company encountered material, which has been tentatively identified as Pantano formation, at a depth of 550 feet and was in it continuously to 1,040 feet. A sample of the formation at 810 feet cut off by the casing shoe from a vertical position is shown in photograph. The dip of the beds is clearly indicated by the photo with the sample in the same relative position it occupied in the hole. The photo shows both sides of the cut.

Drilling was stopped at a depth of 1,150 feet in this hole when the temperature of the water suddenly changed from 82°F. to 110°F. and the salt content increased from 418 ppm to 2,500 ppm, making it unsuitable for cooling purposes. The flow of this bad water was stopped by cementing the hole below the 1,120 feet level. Since it is one of the deepest holes in the center of the valley, the log is presented as an Appendix. It may be noted that no well has been drilled deep enough to strike. metamorphic bedrock in the center of the valley.

GROUND-WATER HYDROLOGY

Definitions

The terms as they are used in the discussion of ground-water hydrology in this paper are briefly defined below in general terms:

Infiltration — The flow or movement of water through the soil surface into the ground. The movement may be comparatively rapid under the force of gravity where large open pores are exposed and very slow if the openings are small or covered with a layer of extremely fine silt or clay.

Porosity — The volume of the pores or interstices between the rock particles of a material, expressed as the ratio in percentage of the volume of pore space to the volume of material in place.

Permeability — The characteristics of a formation which permit it to transmit water. This is effected by the porosity, but more important is the size of the openings between the rock particles, which is determined by the size and arrangement of the particles.

Specific Yield — The volume of water which will drain by gravity from a saturated formation expressed as a percentage of the total volume.

Specific Retention — The ratio of the volume of water retained after draining a saturated formation under the force of gravity expressed as a percentage of the total volume.

Water Table — The upper surface of the zone of saturation where it is under atmospheric conditions and free to rise or fall with changes in the volume of water.

Free Ground Water — Ground water where it is free to move under water table conditions described above.

Ground-Water Artery — Open, porous bed of sand which is enclosed on all sides by less porous formations and connects at the upper end to a source of recharge.

Confined Ground Water — Where the upper surface of the zone of saturation is not free to rise or fall, but is confined by a relatively impervious overlying formation.

Artesian Water — Confined ground water, if under sufficient hydrostatic pressure to cause it to rise above the overlying free ground-water table.

Ground-water Movement

Strictly speaking the term "ground water" as used by the hydrologist, refers only to the water in the zone of saturation.

The movement of subsurface water in the zone of aeration is the result of molecular forces and gravity. The molecular forces tend to hold the water in a thin film on the particle surfaces and are effective over only very short distances. The movement is from the thick to the thinner film surfaces. The amount of water held by molecular forces increases with the total surface area of the particles; consequently, the amount of water held in a clay is much greater than in a sand or gravel. The specific retention of a material represents the water held by molecular forces against gravity.

Water entering the soil by infiltration moves downward in response to molecular and gravitational forces until it reaches the water table. The infiltration from a coarse, sandy stream bed may be very rapid and result in the building up of a ground-water mound or ridge under the stream channel.

Ground-water movement in the zone of saturation in response to gravitational forces is in the direction of the hydraulic gradient. The movement is in the direction of slope of the water table and under free water table conditions, tends to be horizontal, although, it moves around impervious masses and follows the upward and downward course of the more permeable materials. The rate of movement is determined by the permeability, which may vary greatly in distances of only a few feet, but is usually most uniform parallel to the stratification.

The rate of movement of ground water under the normal hydraulic gradients of 16 to 22 feet per mile of the water table is usually very slow. In formations where the velocities are in the order of 5 to 10 feet per day, good wells have been developed. Velocities of from 25 to 50 feet per day are considered high, although velocities of over 400 feet have been reported.[10]

HYDROLOGIC DATA

The data presented are based upon a continuous program of water level measurements since 1947, together with a large number of records obtained prior to the present study. Water level measurements made before 1920 represent virgin conditions, unaffected by pumping. The position of the water table in the trough of the valley at that time was dependent primarily on the depth to which the stream channels had cut into the flow of the inner valley. Small seasonal fluctuations in water levels, due to variation in the use of water by native vegetation occurred, and the wet and dry periods were reflected by a corresponding rise and fall in the water table. The position of the water table along the Santa Cruz was not materially affected from year to year. However, in some areas with open aquifers and good but eratic recharge, such as the Rillito Creek, there may have been rather wide seasonal fluctuations.

Water Level Records

Records from many wells are listed in Table 4 by location. The following information relative to the wells is included in the table in the columns indicated by the numbers: (1) location of well, (2) availability of log of well, (3) depth of well in feet, if known, (4) elevation of measuring point above sea level, if deter-

[10]SMITH, G. E. P., Groundwater Supply and Irrigation in Rillito Valley, Bul. 64, Arizona Agricultural Experiment Station, University of Arizona, p. 131.

mined, (5-6) record and date of earliest water level measurement, if prior to 1947, and (7-17) depth to water in 1940 and 1947-56, inclusive. Under columns 7-17 water level measurements from year to year are comparable, since they are made at each well at approximately the same date in the winter or spring of each year. Measurements made following a period of rest after the heavy pumping season represent most nearly equilibrium conditions and reflect closely the change from year to year of the water table.

No attempt has been made to list all the wells in which water levels have been taken. Only a sufficient number have been included to give a picture of the situation in the various parts of the basin. In some instances a well with only a very short record or only an early measurement is available, however, if it fills a void in the record for that particular area, it is included. Lack of any water level records in a particular area is an indication that there are no wells available.

Ground-water Contour Maps

These are maps upon which are shown the contour lines representing the elevation of the surface of the water table. Usually it is somewhat similar to and superimposed upon a base map with ground surface contours. The ground-water contours are determined by interpolation between elevations of the water surface at the observation wells. (See Plates I and III.)

The elevation above sea level of the measuring points at all wells under study has been determined and from this elevation, the depth to water is subtracted to give the elevation of the water table at that point. This has necessitated the running of more than a thousand miles of instrument level surveys. The accuracy of location of ground-water contours depends on the number of wells available. In areas where wells are scarce or entirely absent, the contour lines are drawn in the most probable locations, or are omitted. In a few areas where the water levels in wells are inconsistent, or the water-bearing quality of the formations is so poor that a definite water table cannot be established, or there is no continuous water table, the elevation of water surface may be shown for individual wells.

The ground-water contour maps for the Santa Cruz Basin are shown in Plates I and II. The contours are for the water levels of the spring of 1956, with a contour interval of 10 feet. *By interpolation between the ground surface contours, the elevation of the ground surface at any point may be estimated and in the same manner, the elevation of the underlying water surface may be determined from the ground-water contours. The difference between the two elevations so determined was the depth to water at that point.*

The ground-water contours indicate the direction of ground-water movement since the flow may be assumed to be at right angles to the contours, or in the direction of steepest slope. A variation in spacing can be interpreted as either due to a change in permeability or in the cross-sectional area of the water-bearing formation. For the same flow to continue through a zone of decreased permeability, a steeper slope of the water table as shown by a closer spacing of the ground-water contours is required. The same condition occurs when there is a constriction in the cross-sectional area of the water-bearing formation and for the same quantity of flow, the velocity must be increased. Extremely flat gradients of the water table are often interpreted to be an indication of favorable conditions for large capacity wells, but it can also mean that only very small quantities of water are flowing through the formation.

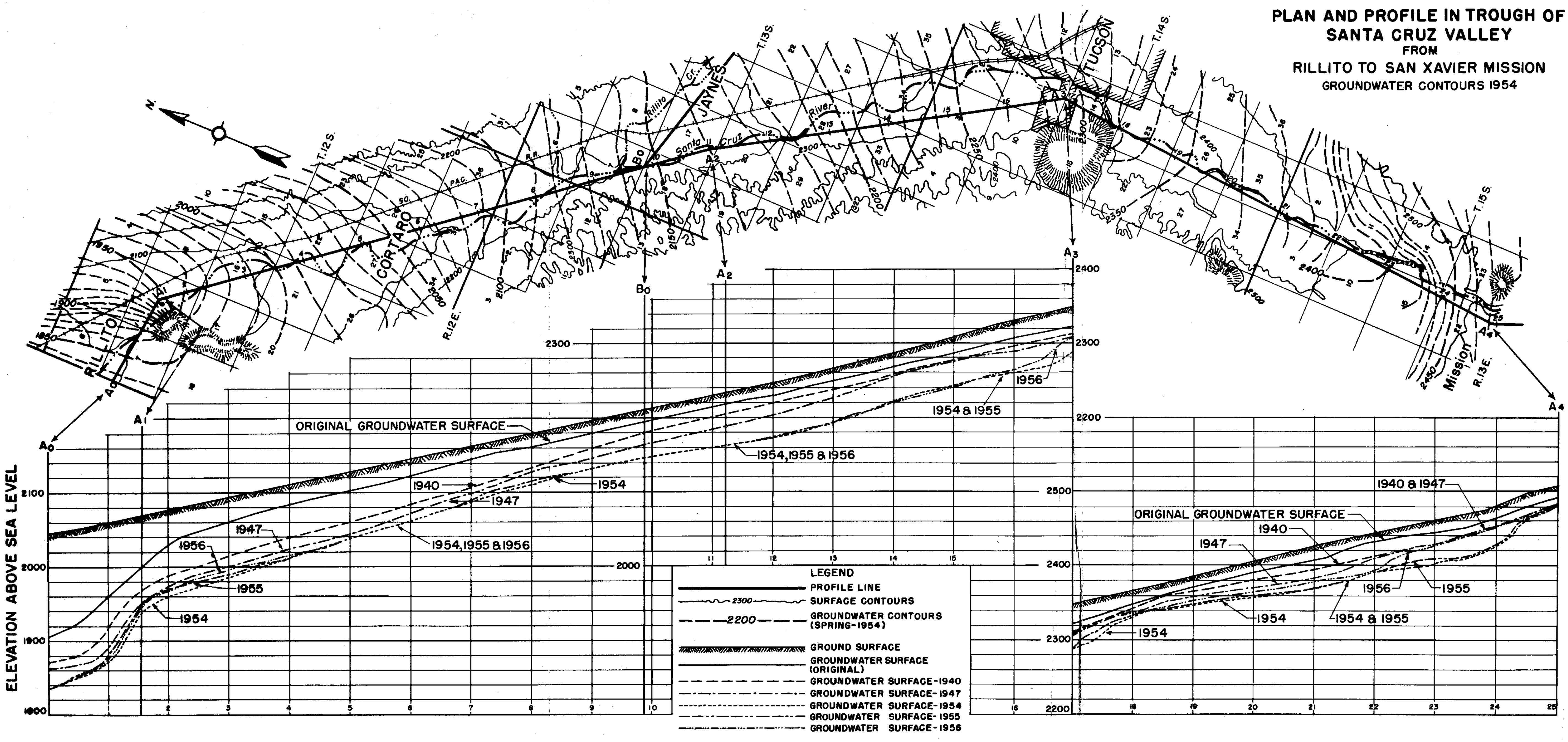

PLAN AND PROFILE IN TROUGH OF
SANTA CRUZ VALLEY
FROM
RILLITO TO SAN XAVIER MISSION
GROUNDWATER CONTOURS 1954
ELEVATION ABOVE SEA LEVEL
ORIGINAL GROUNDWATER SURFACE
ORIGINAL GROUNDWATER SURFACE
RILLITO
CORTARO
JAYNES
TUCSON
Mission
LEGEND
PROFILE LINE
SURFACE CONTOURS
GROUNDWATER CONTOURS (SPRING-1954)
GROUND SURFACE
GROUNDWATER SURFACE (ORIGINAL)
GROUNDWATER SURFACE-1940
GROUNDWATER SURFACE-1947
GROUNDWATER SURFACE-1954
GROUNDWATER SURFACE-1955
GROUNDWATER SURFACE-1956

FIGURE 4

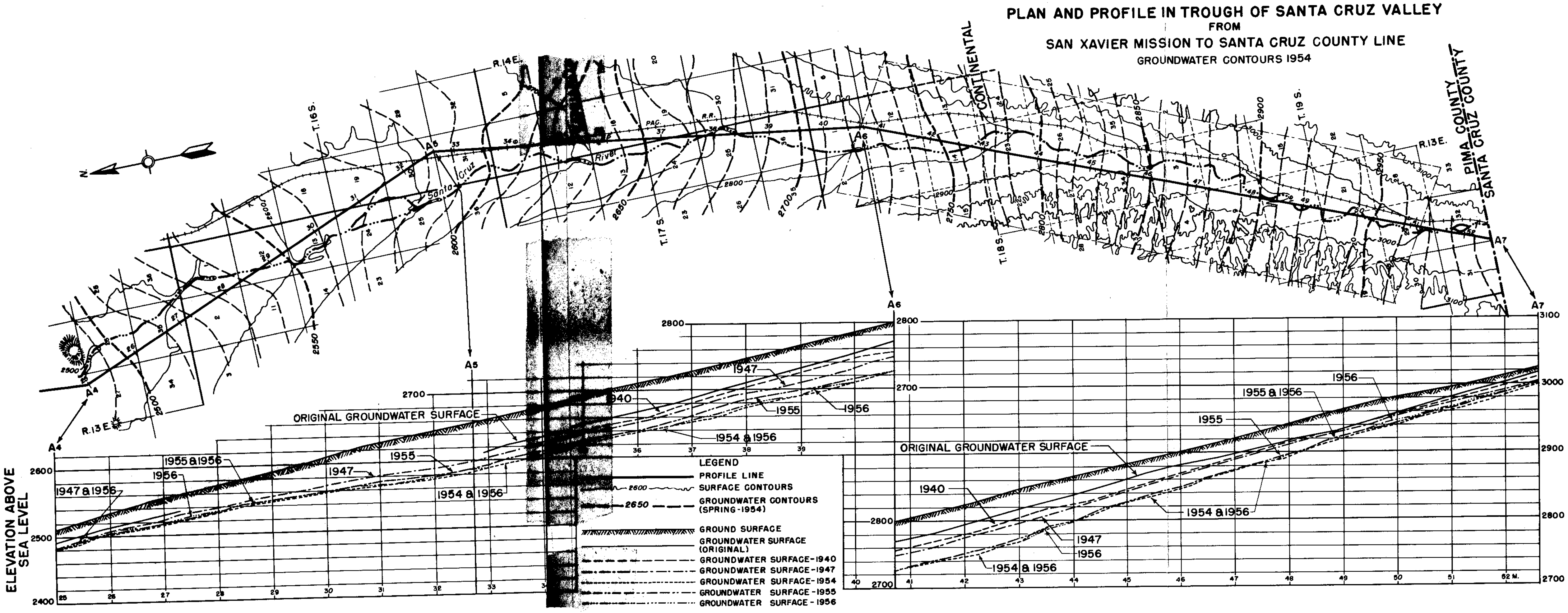

PLAN AND PROFILE IN TROUGH OF SANTA CRUZ VALLEY
FROM
SAN XAVIER MISSION TO SANTA CRUZ COUNTY LINE
GROUNDWATER CONTOURS 1954
CONTINENTAL
PIMA COUNTY
SANTA CRUZ COUNTY
Santa Cruz River
ORIGINAL GROUNDWATER SURFACE
ELEVATION ABOVE SEA LEVEL
LEGEND
PROFILE LINE
SURFACE CONTOURS
GROUNDWATER CONTOURS (SPRING-1954)
GROUND SURFACE
GROUNDWATER SURFACE (ORIGINAL)
GROUNDWATER SURFACE-1940
GROUNDWATER SURFACE-1947
GROUNDWATER SURFACE-1954
GROUNDWATER SURFACE-1955
GROUNDWATER SURFACE-1956

FIGURE 5

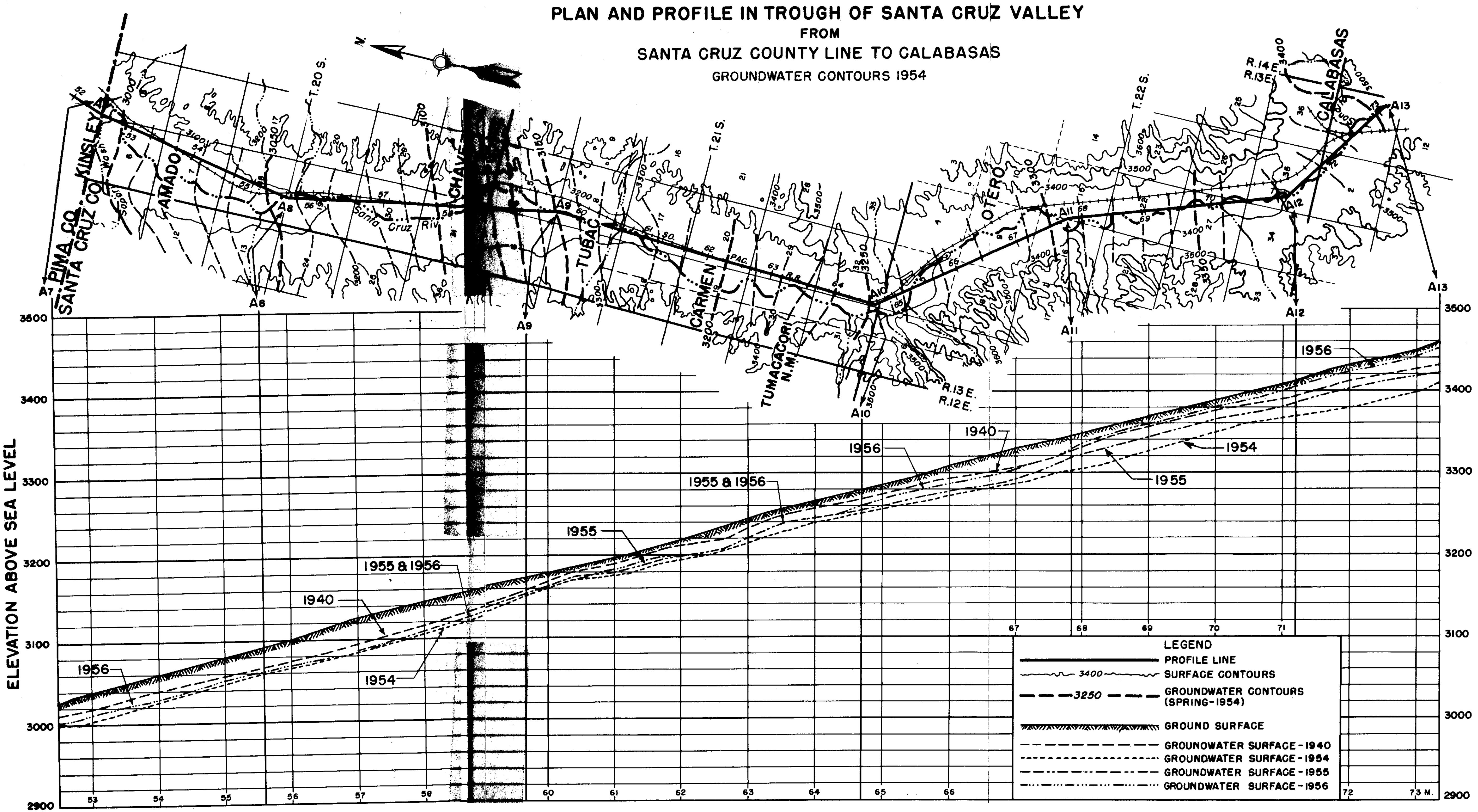
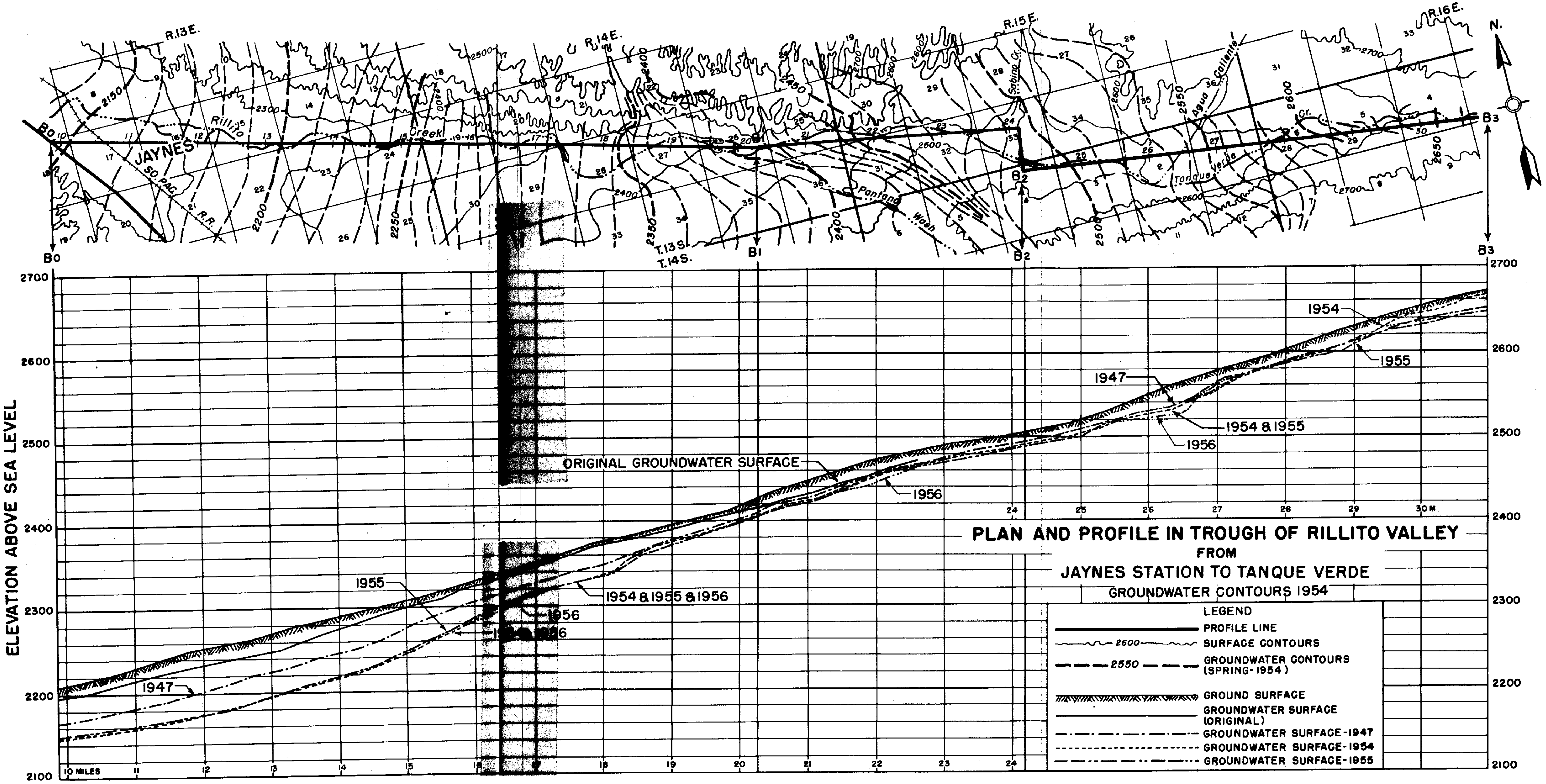

PLAN AND PROFILE IN TROUGH OF SANTA CRUZ VALLEY
FROM
SANTA CRUZ COUNTY LINE TO CALABASAS
GROUNDWATER CONTOURS 1954
N.
PIMA CO.
SANTA CRUZ CO.
KINSLEY
AMADO
CHAVEZ
TUBAC
CARMEN
TUMACACORI N.M.
OTERO
CALABASAS
Santa Cruz Riv.
PAC. R.R.
T.20 S.
T.21 S.
T.22 S.
R.14 E.
R.13 E.
R.12 E.
A7
A8
A9
A10
A11
A12
A13
ELEVATION ABOVE SEA LEVEL
1940
1954
1955
1956
1955 & 1956
LEGEND
PROFILE LINE
SURFACE CONTOURS
GROUNDWATER CONTOURS (SPRING-1954)
GROUND SURFACE
GROUNOWATER SURFACE-1940
GROUNDWATER SURFACE-1954
GROUNDWATER SURFACE-1955
GROUNDWATER SURFACE-1956
73 M.

FIGURE 6



R.13E.
R.14E.
R.15E.
R.16E.
N.
JAYNES
Rillito
Creek
SO. PAC. R.R.
Sabino Cr.
Agua Caliente
Tanque Verde Cr.
Pantano Wash
T.13S.
T.14S.
B0
B1
B2
B3
ELEVATION ABOVE SEA LEVEL
ORIGINAL GROUNDWATER SURFACE
1947
1954
1955
1956
1954 & 1955
1954 & 1955 & 1956
10 MILES
PLAN AND PROFILE IN TROUGH OF RILLITO VALLEY
FROM
JAYNES STATION TO TANQUE VERDE
GROUNDWATER CONTOURS 1954
LEGEND
PROFILE LINE
2600 SURFACE CONTOURS
2550 GROUNDWATER CONTOURS (SPRING-1954)
GROUND SURFACE
GROUNDWATER SURFACE (ORIGINAL)
GROUNDWATER SURFACE-1947
GROUNDWATER SURFACE-1954
GROUNDWATER SURFACE-1955

FIGURE 7

Order of sections in township

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

Order of sixteenths in section

D	C	B	A
E	F	G	H
L	K	J	I
M	N	O	P

Table 4 -- LIST OF WELLS GIVING: LOCATION, DEPTH, MEASURING POINT ELEVATION, AND INITIAL 1940 and 1947-1956, INCLUSIVE, RECORDS OF DEPTH TO WATER

Location* in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface: First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
						Township 10 South, Range 14 East										
25-J	No	-	3200.6	1954	-	-	-	-	-	-	-	-	-	208.8	208.9	209.2
27-L	No	361	3317.5	1954	-	-	-	-	-	-	-	-	-	347.6	348.2	348.2
29-O	No	-	3273.4	1954	-	-	-	-	-	-	-	-	-	317.6	309.4	315.5
						Township 11 South, Range 12 East										
31-J	Yes	500	2052.7	1953	-	-	-	-	-	-	-	-	164.1	165.8	166.6	167.5
31-M	No	-	2036.3	1951	-	-	-	-	-	-	184.0	190.5	195.2	202.9	222.0	197.6
31-O	No	-	-	1915	128.2/	-	-	-	-	-	-	-	-	-	-	-
31-P	No	420	2055.6	1945	131.7	-	133.9	135.0	136.4	137.9	138.1	140.4	141.6	142.8	143.7	145.9
34-P	No	483	2392.1	1952	-	-	-	-	-	-	-	369.2	-	373.2	-	373.5
36-N	Yes	551	2592.0	1931	470	-	-	-	478.5	478.5	480.8	480.0	480.7	481.3	482.4	482.9
						Township 11 South, Range 13 East										
24-O	No	-	2892.2	1955	-	-	-	-	-	-	-	-	-	-	96.2	80.0
33-I	No	608	2814.1	1948	-	-	-	564.6	-	-	558.6	559.2	560.1	-	552.2	559.4
34-J	Yes	578	2816.5	1948	-	-	-	532.6	-	517.3	519.5	520.1	522.0	522.1	522.8	525.0
36-D	No	510	2903.0	1931	423	-	-	-	439.4	439.0	440.5	444.9	443.7	449.9	455.6	447.2
						Township 11 South, Range 14 East										
2-K	No	-	3127.4	1954	-	-	-	-	-	-	-	-	-	166.2	165.7	166.2
2-N	No	-	3041.2	1941	13.8	-	-	-	-	-	-	-	-	90.2	89.7	92.2
4-D	No	280	3162.2	1951	-	-	-	-	-	-	234.0	-	-	234.7	-	-
4-M	No	-	3126.5	1954	-	-	-	-	-	-	-	-	-	222.1	219.0	213.1
11-D	No	-	3009.3	1954	-	-	-	-	-	-	-	-	-	63.3	93.4	90.5

*Number indicates order of section in township. Letter indicates order of sixteenth in section. For example, J is the northwest 1/4 of southeast 1/4 of section.

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface: First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
Township 11 South, Range 14 East (continued)																
22-E	No	-	2921.4	1941	78.0	-	-	-	-	-	-	-	-	104.7	105.1	106.8
26-C	No	-	2960.8	1941	110.0	-	-	-	-	-	-	-	-	177.9	179.9	109.7
28-G	Yes	202	2845.0	1944	149.6	-	-	-	-	-	-	-	163.5	165.7	167.2	168.3
28-M	Yes	350	2804.4	1953	-	-	-	-	-	-	-	-	147.0	152.0	156.4	-
28-N	Yes	200	2816.1	1953	-	-	-	-	-	-	-	-	152.5	155.1	157.3	157.8
30-L	No	203	2775.3	1955	-	-	-	-	-	-	-	-	-	-	201.9	-
30-M	No	-	2744.1	1955	-	-	-	-	-	-	-	-	-	-	204.0	204.2
31-G	Yes	466	2703.3	1953	-	-	-	-	-	-	-	-	174.6	171.5	173.1	172.9
32-M	No	-	2662.5	1958	-	-	-	120.6	126.2	127.5	-	132.3	-	138.1	137.2	134.9
34-M	Yes	99	2719.2	1953	-	-	-	-	-	-	-	-	58.8	60.2	60.0	67.1
Township 12 South, Range 12 East																
1-M	No	-	2471.9	1948	-	-	-	363.7	364.4	365.7	367.0	367.4	368.5	369.2	370.1	370.8
4-D	No	-	2176.1	1953	-	-	-	-	-	-	-	-	209.9	-	211.2	212.1
5-D	Yes	469	2055.5	1950	-	-	-	-	-	143.0	143.8	146.1	148.3	150.4	151.3	151.5
5-F	No	188	2061.0	1929	105.4	111.0	122.8	124.0	126.7	129.9	130.2	-	137.7	139.3	138.5	138.9
5-M	Yes	223	2058.7	1924	101.0	120.2	136.9	155.9	-	154.1	-	-	-	-	-	-
5-P	No	200	2073.4	1915	48.9	-	-	-	-	-	113.7	120.3	122.8	125.1	122.4	121.6
6-C	Yes	623	2044.2	1940	-	153.5	-	-	-	179.4	179.2	184.6	187.1	188.1	187.3	187.1
6-F	No	-	2046.8	1952	-	-	-	-	-	-	-	181.1	-	196.2	-	175.1
6-G	No	236	2046.5	1949	-	-	-	-	174.4	177.5	178.2	184.2	190.4	197.7	196.2	195.1
8-B	Yes	250	2071.1	1915	39.7	-	108.3	112.9	114.6	115.2	112.3	118.1	120.7	122.5	118.2	117.6
8-D	No	-	2059.9	1948	-	-	-	169.2	-	174.8	172.8	179.6	176.9	188.0	186.0	185.1
8-F	No	120	2070.1	1923	74.6	98.7	112.4	116.0	-	-	-	-	-	-	-	-
8-J	Yes	261	2071.4	1922	36.4	79.5	95.6	97.9	101.3	101.9	98.7	103.9	107.6	116.7	105.3	104.8
9-D	No	-	2096.7	1950	-	-	-	-	-	128.0	124.6	130.0	131.6	134.3	131.5	128.1
9-E	Yes	130	2091.5	1917	34.7	98.2	-	-	120.4	-	117.0	-	-	-	-	-
9-E	Yes	199	2080.6	1949	-	-	-	-	108.2	108.9	104.4	111.1	113.3	115.6	111.6	106.3
12-D	Yes	395	2444.9	1933	325.6	328.8/	-	-	-	-	-	-	-	-	-	-
14-H	Yes	300	2343.3	1932	246.6	249.3	-	-	263.3	265.4	265.9	267.1	268.6	269.9	274.3	272.3
15-J	No	164	2185.3	1924	107.2	-	155.0	158.4/	-	-	-	-	-	-	-	-
15-J	No	260	2191.5	1948	-	-	-	164.2	163.5	164.7	162.5	167.2	168.6	169.7	169.5	166.5

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
				Depth to water in feet from measuring point, at approximate ground surface												
				Township 12 South, Range 12 East (continued)												
15-N	No	-	2131.3	1951	-	-	-	-	-	-	109.4	115.6	115.3	-	115.0	113.0
16-C	Yes	300	2087.0	1922	35.6	74.7	93.8	94.6	98.4	97.7	94.6	99.3	102.2	107.1	102.4	100.0
16-D	Yes	340	2080.9	1921	39.0	75.0	92.2	95.8	98.4	100.5	97.4	102.5	105.3	110.1	102.5	101.9
16-F	Yes	346	2090.8	1921	35.6	75.4	91.9	94.9	99.3	98.9	95.6	100.2	105.1	107.2	102.5	-
16-L	Yes	260	2089.3	1921	34.7	70.9	87.0	91.2	97.0	94.6	91.0	96.2	100.3	105.5	99.4	96.3
16-P	Yes	234	2102.7	1930	69.2	67.9	83.4	87.0	91.6	90.6	87.5	91.4	95.9	98.3	94.3	91.7
17-I	Yes	416	2085.7	1921	31.8	69.5	87.1	88.7	95.0	94.7	91.5	96.3	100.5	103.7	99.4	96.7
17-P	Yes	208	2096.0	1921	34.0	72.0	92.2	92.6	97.8	97.1	92.0	98.4	102.1	105.1	99.3	98.1
20-A	Yes	386	2099.1	1921	31.0	71.8	88.9	91.9	96.6	96.0	92.6	98.6	102.2	105.2	103.2	98.2
20-N	Yes	154	2148.5	1934	100.8	111.1	133.9	-	-	135.8	133.8	137.1	138.3	140.1	-	134.9
21-C	Yes	409	2103.4	1921	32.4	74.2	93.6	95.5	100.0	101.0	96.0	100.3	105.2	107.4	105.4	100.2
21-F	Yes	403	2107.7	1921	36.0	70.7	89.0	92.3	94.9	96.4	94.0	98.4	101.5	104.9	100.9	98.1
21-K	Yes	225	2111.3	1929	74.0	73.0	89.5	94.3	93.6	98.2	94.7	99.2	103.9	105.7	101.4	98.7
21-O	Yes	280	2115.9	1921	35.8	73.1	90.9	93.6	98.3	98.1	94.3	99.0	102.6	103.5/	-	-
21-O	No	-	2119.5	1955	-	-	-	-	-	-	-	-	-	-	100.9	98.3
22-D	No	-	2112.4	1950	-	-	-	-	-	94.0	90.1	96.7	96.6	98.1	94.7	93.3
22-H	Yes	315	2139.4	1942	92.4	-	-	102.5	105.6	106.2	102.3	108.1	108.3	109.6	107.2	105.8
22-O	No	-	2122.1	1955	-	-	-	-	-	-	-	-	-	-	91.0	89.6
22-P	Yes	316	2132.5	1924	36.0	71.7	85.1	89.3	93.6	92.2	90.3	92.8	95.3	96.5	94.1	93.3
24-J	Yes	208	2291.9	1930	172.9	177.2	-	190.7	192.4	193.7	193.8	196.1	196.8	198.2	198.5	198.2
25-K	Yes	238	2172.2	1942	75.2	-	81.9	84.6	89.9	88.2	87.7	88.9	90.5	92.9	91.0	90.8
26-E	Yes	312	2147.6	1939	74.3	72.7	81.9	87.9	89.6	89.9	89.5	91.4	92.9	94.6	92.8	92.0
26-J	Yes	248	2159.2	1923	40.6	71.2	81.6	84.6	91.1	89.0	84.9	89.6	91.7	92.8	90.8	90.6
27-L	Yes	160	2132.1	1920	44.1	78.8	95.0	98.9	103.3	102.7	99.8	103.6	106.7	108.0	105.2	103.0
27-O	Yes	246	2137.2	1944	81.5	-	83.0	86.9	91.4	90.4	89.2	92.0	93.0	94.8	91.6	90.6
28-P	Yes	158	2168.1	1920	77.2	113.6	131.9	136.5	141.0	141.6	137.2	142.7	143.8	145.2	142.5	140.1
29-F	Yes	250	2157.5	1948	-	-	-	139.8	-	144.6	139.9	145.7	147.2	148.9	146.4	143.7
29-J	No	-	2178.8	1950	-	-	-	-	-	166.0	161.2	167.4	168.5	170.0	169.6	-
26-P	No	-	2175.5	1937	134.3	134.2	151.9	154.0	161.5	-	-	-	163.7	164.1	-	-
33-F	Yes	232	2208.0	1935	155.0	176.9	178.8	177.5	-	183.7	182.2	181.6	181.0	184.9	181.2	180.4
33-G	Yes	230	2206.2	1935	150.3	160.3	173.4	176.0	-	180.3	179.8	188.2	184.3	189.8	187.4	185.6
33-H	Yes	285	2215.4	1943	171.5	-	180.8	183.9	185.7	187.9	190.7	192.4	192.5	194.7	195.4	194.2
33-I	Yes	342	2239.1	1931	150.5	167.1	-	158.4	158.9	-	-	-	-	-	-	-
33-M	Yes	210	2264.1	1938	135.6	137.0	140.8	141.3	141.9	142.4	-	144.3	145.0	145.4	146.7	146.9
34-B	Yes	214	2143.7	1920	29.0	69.7	-	86.6	90.1	90.0	87.9	89.9	90.1	92.2	89.6	-

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface												
				First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
				Township 12 South, Range 12 East (continued)												
34-I	No	138	2196.8	1947	-	-	123.3	-	129.0	129.9	128.8	129.8	-	-	-	-
34-P	Yes	159	2207.3	1931	117.1	118.8	127.7	131.7	132.5	134.1	133.0	134.5	134.5	135.9	134.3	133.7
35-H	Yes	115	2168.1	1922	28.0	63.8	73.3	76.6	81.0	80.4	79.5	79.9	81.6	84.6	84.9	81.6
35-L	No	-	2156.5	1949	-	-	-	-	83.1	83.5	82.0	82.0	82.3	84.4	82.1	82.9
36-C	Yes	207	2172.3	1924	38.1	66.4	-	82.3	-	91.9	84.9	87.1	87.6	90.1	88.0	87.7
36-N	Yes	347	2177.2	1920	22.5	54.9	65.8	69.5	73.0	73.7	72.8	72.2	73.9	76.2	74.2	74.7
				Township 12 South, Range 13 East												
2-B	Yes	501	2808.8	1955	-	-	-	-	-	-	-	-	-	-	435.4	436.6
6-P	Yes	510	2626.0	1939	465.0	-	-	-	-	461.5	462.6	463.3	464.0	-	-	-
8-E	Yes	-	2592.1	1954	-	-	-	-	-	-	-	-	-	430.1	429.1	-
8-I	No	-	2620.1	1938	405.5	-	413.8	414.2	415.5	416.5	418.2	419.3	421.9	422.8	423.7	425.1
8-M	No	442	2531.5	1955	-	-	-	-	-	-	-	-	-	-	374.5	-
12-K	No	-	2523.5	1932	129.4	139.6	-	155.7	151.6	152.4	154.7	156.6	158.2	160.0	161.2	161.8
13-O	Yes	315	2605.6	1925	262.0	-	-	-	-	-	-	-	-	-	-	-
14-I	No	-	2481.8	1932	145.2	153.2	159.8	160.7	164.0	163.9	166.0	168.2	170.1	171.6	172.1	173.5
14-N	No	206	2456.4	1930	138.4	-	-	155.7	157.4	158.7	160.5	162.2	167.2	165.3	166.6	167.7
15-O	No	-	2418.3	1954	-	-	-	-	-	-	-	-	-	193.2	193.8	193.0
16-N	Yes	400	2521.8	1932	311.9	317.3	324.3	324.5	326.8	328.5	330.2	332.1	335.4	336.9	338.6	340.1
17-P	Yes	430	2515.4	1938	322.9	324.4	335.0	333.6	334.9	336.4	338.4	340.0	343.1	345.0	341.7	347.7
18-A	Yes	456	2504.5	1932	331.2	335.8	342.9	344.9	346.4	347.6	349.7	351.3	352.3	353.4	354.8	357.2
21-C	Yes	424	2506.6	1948	-	-	-	310.3	311.6	313.4	315.1	317.1	322.8	322.4	324.5	330.9
21-D	No	-	2484.9	1953	-	-	-	-	-	-	-	-	312.2	313.9	315.7	316.9
22-D	Yes	268	2424.3	1936	194.4	197.3	203.7	204.8	206.0	207.5	-	211.2	214.9	216.7	218.2	219.2
22-K	No	-	2384.6	1952	-	-	-	-	-	-	-	166.5	169.7	174.4	175.6	176.1
23-P	Yes	380	2546.5	1946	268.2	-	270.1	271.0	272.5	274.0	275.8	277.4	280.5	-	283.4	288.0
24-B	Yes	470	2619.5	1948	-	-	-	307.0	-	309.8	311.6	313.2	316.9	317.5	318.9	320.1
26-K	No	-	2516.3	1955	-	-	-	-	-	-	-	-	-	-	-	238.5
28-A	No	300	2361.7	1954	-	-	-	-	-	-	-	-	-	180.2	179.8	180.0
28-B	No	405	2356.7	1954	-	-	-	-	-	-	-	-	-	182.4	181.2	180.8
28-H	No	-	2351.4	1954	-	-	-	-	-	-	-	-	-	172.3	172.7	172.0

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface: First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
Township 12 South, Range 14 East																
3-D	No	-	2711.2	1953	-	-	-	-	-	-	-	-	29.4	17.6	41.4	66.9
4-B	No	-	2694.0	1953	-	-	-	-	-	-	-	-	49.3	45.0	56.5	64.9
5-D	No	400	2657.8	1953	-	-	-	-	-	-	-	-	139.4	141.9	139.9	138.1
5-G	No	-	2651.1	1940	101.6	104.1	106.0/	-	-	-	-	-	-	-	-	112.7
5-G	No	-	2659.5	1955	-	-	-	-	-	-	-	-	-	-	93.1	-
5-H	Yes	-	2687.1	1953	-	-	-	-	-	-	-	-	67.8	67.2	68.0	68.6
5-N	Yes	-	2625.2	1940	-	100.5	100.5	103.4	108.8	-	118.0	120.6	118.4	116.4	108.7	98.2
7-B	Yes	130	2587.1	1924	96.8	-	-	-	-	-	-	-	-	-	153.4	154.0
7-F	No	250	2575.5	1947	-	-	140.2	141.0	144.2	147.1	150.6	153.1	159.1	157.7	156.8	157.7
Township 13 South, Range 12 East																
1-F	Yes	258	2181.6	1920	18.3	47.4	58.5	63.6	67.1	67.4	66.8	63.9	66.8	73.5	68.3	70.0
1-I	Yes	201	2187.2	1924	20.0	42.1	54.8	59.3	61.8	64.5	64.1	61.0	63.8	69.3	65.8	67.6
2-A	No	-	2168.1	1953	-	-	-	-	-	-	-	-	66.8	70.3	66.7	68.3
2-B	No	-	2176.6	1924	37.6	68.1	77.0	80.4	83.3	84.7	83.0	-	83.1	86.3	82.3	84.0
2-I	No	154	2228.0	1948	-	-	-	114.3	117.6	119.7	118.1	117.1	117.7	122.1	118.0	119.8
2-O	Yes	300	2244.1	1950	-	-	-	-	-	129.0	127.7	127.7	128.0	132.5	129.4	130.1
3-F	Yes	202	2251.2	1949	-	-	-	-	102.7	103.4	103.8	104.3	104.5	105.0	105.7	106.8
3-F	Yes	212	2283.1	1933	129.7	133.9	147.2	149.6	148.2/	-	-	-	-	-	-	-
3-L	No	300	2327.5	1947	-	-	252.6	256.5	272.5	271.3	226.2	148.0	101.7	95.9	95.3	95.1
4-A	No	345	2298.0	1953	-	-	-	-	-	-	-	-	214.1	216.4	216.6	216.8
4-B	No	-	2276.4	1947	-	-	243.0	223.7	233.4	209.1	229.7	195.8	176.6	142.2	143.3	143.8
4-C	Yes	302	2276.6	1942	140.0	-	-	-	154.8	154.2	-	156.2	156.9	158.1	158.7	-
4-O	No	-	2382.1	1950	-	-	-	-	-	141.6	-	143.1	145.9	143.5	144.3	145.5
11-C	No	285	2316.4	1950	-	-	-	-	-	193.2	193.8	195.0	195.0	196.6	196.1	196.5
12-A	Yes	-	2191.5	1948	-	-	-	56.9	59.9	62.9	62.2	60.7	61.4	68.1	67.3	65.8
12-C	No	-	2218.2	1931	67.8	74.7	85.8	90.0	93.1	95.5	93.4	93.6	93.2	96.6	95.7	97.7
13-A	No	155	2282.7	1953	-	-	-	-	-	-	-	-	139.0	136.8	135.6	135.3
13-P	No	200	2336.7	1950	-	-	-	-	-	174.4	177.1	179.6	181.8	185.1	183.9	184.6
24-F	Yes	-	2391.0	1931	196.5	-	206.8	207.7	212.1/	-	-	217.8	-	-	-	225.1
25-H	No	292	2445.3	1946	25.0	-	-	-	-	-	-	-	-	-	-	-
25-J	Yes	411	2473.5	1947	-	-	225.3	225.9	221.4	227.0	-	231.3	231.4	233.4	-	230.7
25-P	No	360	2449.8	1947	-	-	247.3	250.5	255.5	253.3	-	256.2	256.8/	-	-	-

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface: First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
Township 13 South, Range 13 East																
1-A	Yes	530	2602.7	1947	-	-	365.6	366.7	358.7	370.8	373.1	375.5	-	-	-	385.7
1-L	No	351	2523.8	1933	280.5	286.6	293.9/	-	-	-	-	-	-	-	-	-
1-N	Yes	-	2507.6	1954	-	-	-	-	-	-	-	-	-	293.8	296.2	298.8
2-F	Yes	360	2482.2	1947	-	-	256.1	256.6	258.2	260.3	262.6	265.1	267.8	272.4	272.5	274.8
3-H	Yes	385	2420.8	1955	-	-	-	-	-	-	-	-	-	-	228.4	-
3-I	No	-	2423.6	1955	-	-	-	-	-	-	-	-	-	-	233.4	234.2
3-O	Yes	239	2376.7	1946	170.4	-	171.8	174.2	177.1	180.2	182.0	185.6	188.2	192.1	194.3	196.0
5-D	Yes	294	2245.9	1944	101.0	-	105.2	109.8	112.7	115.5	115.6	117.7	120.0	123.4	121.7	121.9
5-N	No	-	2228.1	1908	34.9/	-	-	-	-	-	-	-	-	-	-	-
6-A	No	-	2246.2	1952	122.6	-	-	-	-	-	-	-	123.2	126.5	124.7	124.8
6-D	Yes	355	2210.0	1921	49.9	73.9	86.5	91.2	94.3	96.4	96.3	97.5	98.8	103.4	100.4	100.7
6-F	Yes	440	2213.0	1919	42.5	65.9	76.8	82.9	85.6	88.4	88.2	87.0	89.3	94.0	90.6	91.2
6-I	No	-	2236.6	1909	52.7/	-	-	-	-	-	-	-	-	-	-	-
6-I	Yes	228	2233.7	1949	-	-	-	-	97.9	100.7	-	103.5	104.6	108.1	106.3	106.3
7-A	No	-	2222.0	1908	28.7/	-	-	-	-	-	-	-	-	-	-	-
7-H	Yes	182	2215.2	1947	-	-	56.6	-	64.2	69.4	68.3	68.7	71.7	74.9	72.7	74.2
8-B	No	-	2235.7	1907	37.1/	-	-	-	-	-	-	-	-	-	-	-
8-B	Yes	300	2248.3	1921	55.7	75.2	90.0	95.1	96.9	100.3	100.8	103.9	105.2	109.5	107.0	108.2
8-C	No	180	2233.8	1947	-	-	77.8	-	83.7	87.2	87.3	89.7	91.4/	94.9	93.8	94.9
8-H	No	-	2237.6	1952	-	-	-	-	-	-	-	82.9	-	92.2	87.4	-
8-N	No	124	2235.0	1947	-	-	61.1	65.6	66.9	71.9	72.9	75.0	78.0	82.8	79.3	81.5
9-E	Yes	253	2250.0	1921	41.8	60.3	76.0	80.4	81.5	84.3	85.1	88.8	92.6	96.9	94.2	95.1
9-L	No	-	2240.5	1908	37.8/	-	-	-	-	-	-	-	-	-	-	-
9-O	No	170	2259.2	1949	-	-	-	-	79.7	83.5	-	87.5	90.5	94.4	93.7	94.5
10-C	No	-	2359.9	1934	145.1	149.9	156.5	159.3	-	163.3	-	172.2	-	180.4	180.9	182.8
11-D	Yes	310	2411.5	1949	-	-	-	-	200.0	203.2	206.9	210.8	214.3	218.1	220.8	222.2
12-E	No	-	2463.1	1952	-	-	-	-	-	-	-	245.1	248.8	252.7	255.5	258.1
12-F	No	-	2435.5	1929	180.5	-	195.9	198.1	202.0	205.7	210.7	214.1	217.8	211.6	224.9	227.5
12-G	Yes	340	2504.8	1952	-	-	-	-	-	-	-	279.4	283.1	287.1	296.8	-
12-M	No	188	2386.4	1929	131.9	-	149.2	155.1	158.0	159.1	163.2	167.5	171.9	-	-	-
13-D	Yes	242	2378.5	1948	-	-	-	142.9	147.5	151.9	156.4	160.9	164.4	169.7	173.4	174.6
13-M	No	125	2308.2	1930	35.1	42.4/	-	-	-	-	-	-	-	-	-	-
13-N	No	-	2325.2	1947	-	-	66.9	73.6	77.9	83.2	-	88.8	91.8	-	99.4	100.6
13-P	No	-	2328.5	1909	18.7/	-	-	-	-	-	-	-	-	-	-	-
13-P	Yes	200	2360.0	1947	-	-	85.2	90.6	-	99.6	103.7	107.6	109.1	114.2	117.2	118.5

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface: First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
								Township 13 South, Range 13 East (continued)								
14-L	Yes	153	2288.1	1947	-	-	59.4	63.0	66.6	71.9	75.1	80.3	84.0	88.0	89.5	90.5
14-P	No	270	2307.0	1947	-	-	61.2	68.3	72.3	78.4	80.6	84.5	88.4	92.9	94.6	96.1
15-F	No	-	2273.8	1908	32.4/	-	-	-	-	-	-	-	-	-	-	-
15-I	No	-	2279.0	1935	39.3	44.5	53.2	-	-	-	-	75.3	78.5	83.4	-	-
15-M	No	-	2272.2	1950	-	-	-	-	-	70.5	72.2	80.3	84.5	87.9	87.1	87.5
16-A	No	-	2262.9	1955	-	-	-	-	-	-	-	-	-	-	87.4	88.1
16-I	No	-	2262.4	1955	-	-	-	-	-	-	-	-	-	-	84.5	85.0
16-L	No	-	2249.8	1953	-	-	-	-	-	-	-	-	80.5	84.8	82.6	-
16-O	No	-	2265.8	1907	26.0/	-	-	-	-	-	-	-	-	-	-	-
17-B	No	-	2232.1	1909	27.5/	-	-	-	-	-	-	-	-	-	-	-
17-C	No	-	2234.2	1950	-	-	-	-	-	70.4	73.7	72.3	-	78.8	76.2	78.8
17-H	No	181	2248.6	1947	-	-	60.3	64.8	67.0	71.4	73.8	-	81.7	85.6	83.3	84.8
17-I	No	96	2247.2	1938	39.8	41.3	55.4	59.8	62.6	67.7	69.6	-	77.8	82.2	80.0	81.2
17-K	Yes	131.5	2239.4	1947	-	-	54.8	59.7	-	66.5	-	72.3	73.9	79.1	76.0	78.8
17-O	No	-	2243.7	1940	-	36.8	50.8	56.4	-	63.5	66.1	72.0	74.0	78.7	76.4	77.6
18-G	No	-	2230.3	1947	-	-	60.8	-	-	72.1	72.3	75.2	77.2	80.9	78.6	80.1
19-C	No	-	2359.0	1952	-	-	-	-	-	-	-	199.0	201.1	205.2	201.8	-
19-P	No	228	2348.3	1947	-	-	156.7	161.4	-	169.7	172.3	177.9	180.9	185.0	183.8	184.4
20-D	No	-	2249.7	1947	-	-	65.9	-	-	77.0	81.0	85.0	87.0	91.2	86.6	90.8
20-O	No	-	2263.1	1908	33.3/	-	-	-	-	-	-	-	-	-	-	-
20-P	No	-	2259.1	1947	-	-	55.7	58.6	-	68.7	71.3	79.1	83.8	87.7	86.6	86.7
21-D	No	-	2248.1	1947	-	-	47.3	51.8	54.8	58.7	62.7	70.1	-	-	-	-
21-I	Yes	61	2264.3	1947	-	-	39.5	44.0	47.5	54.4	55.3/	70.8	74.4	78.2	77.5	77.3
21-N	Yes	251	2267.2	1951	-	-	-	-	-	-	64.8	-	77.3	80.8	80.9	80.1
22-C	No	-	2282.5	1908	30.1/	-	-	-	-	-	-	-	-	-	-	-
22-C	Yes	161	2282.1	1947	-	-	54.5	58.5	61.3	69.8	73.0	-	84.2	-	82.4	-
22-D	Yes	165	2283.1	1947	-	-	64.2	67.9	71.0	77.6	81.3	-	-	-	94.3	-
22-F	Yes	162	2298.0	1947	-	-	72.9	78.4	80.3	88.3	88.9	-	96.6	104.4	104.0	88.5
22-I	Yes	220	2312.3	1948	-	-	-	72.4	80.4	-	91.4	96.4	99.5	104.2	104.9	104.8
23-A	No	-	2304.0	1907	12.2/	-	-	-	-	-	-	-	-	-	-	-
23-E	Yes	196	2304.7	1920	43.5	-	63.4	66.6	69.0	73.9	79.9	84.4/	-	-	-	-
23-E	No	200	2301.9	1953	-	-	-	-	-	-	-	-	79.4	94.1	88.6	94.8
23-H	No	-	2307.3	1909	22.7/	-	-	-	-	-	-	-	-	-	-	-
23-L	No	-	2308.2	1947	-	-	66.0	-	72.2	76.9	78.1	-	-	-	-	-

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface — First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
								Township 13 South, Range 13 East (continued)								
24-A	No	-	2312.3	1909	9.2/	-	-	-	-	-	-	-	-	-	-	-
24-A	Yes	130	2321.9	1946	41.5	-	38.9	-	50.9	-	59.8	58.4	-	71.7	73.7	73.6
24-E	No	-	2310.5	1946	49.0	-	53.9	58.2	61.9	67.9	70.9	74.6	77.6	83.4	84.8	85.5
24-F	No	-	2313.8	1946	45.1	-	50.0	55.4	58.1	63.4	66.5	68.7	73.4	78.4	80.0	81.4
24-I	No	-	2323.8	1909	8.6/	-	-	-	-	-	-	-	-	-	-	-
24-N	No	-	2327.8	1953	-	-	-	-	-	-	-	-	78.3	80.6	85.4	86.8
25-A	No	-	2345.9	1950	-	-	-	-	-	64.8	68.4	71.9	74.2	78.7	81.5	83.4
25-B	No	-	2332.4	1946	47.8	-	51.3	56.8	58.4	62.4	66.0	69.8	-	-	-	-
25-F	No	-	2338.4	1950	-	-	-	-	-	79.5	82.6	87.1	89.9	93.1/	-	-
26-A	No	-	2328.1	1907	39.0/	-	-	-	-	-	-	-	-	-	-	-
26-A	No	-	2325.4	1952	-	-	-	-	-	-	-	88.3	91.8	96.1	98.2	99.3
26-C	Yes	222	2321.7	1954	-	-	-	-	-	-	-	-	-	99.5	101.8	102.8
26-D	Yes	200	2318.0	1947	-	-	73.6	75.9	78.9	-	87.5	-	92.6	101.8	103.8	104.5
26-F	Yes	216	2321.6	1946	67.8	-	-	-	72.8	79.0	81.9	87.3	91.7	96.0	97.3	98.7
26-I	No	-	2328.3	1947	-	-	66.6	68.9	70.1	-	79.8	84.1	88.2	92.1	93.8	-
26-M	No	376	2308.5	1953	-	-	-	-	-	-	-	-	81.1	86.3	87.0	89.3
26-N	Yes	220	2321.3	1947	-	-	65.4	-	66.8	77.0	81.1	81.7	85.4	90.5	91.6	92.8
27-G	No	-	2296.1	1907	30.7/	-	-	-	-	-	-	-	-	-	-	-
27-G	No	137	2299.8	1947	-	-	53.6	58.1	58.3	66.3	66.7	74.0	77.4	82.1	82.9	83.6
27-I	No	-	2305.5	1947	-	-	57.8	61.0	61.4	69.3	71.8	-	81.0/	-	-	-
28-A	No	154	2271.0	1947	-	-	43.1	-	51.0	54.9	-	-	74.4	-	77.5	77.3
28-H	No	-	2280.0	1908	22.3/	-	-	-	-	-	-	-	-	-	-	-
28-H	No	168	2279.3	1940	329.0	-	46.1	47.7	49.8	54.8	60.2	68.9	73.9	-	-	76.3
28-M	No	-	2298.2	1947	-	-	74.0	78.2	82.2	86.7	90.5	-	105.3	108.9	109.7	108.2
28-P	Yes	75	2284.3	1935	28.7	-	38.9	43.3	-	-	-	63.8	69.1	-	-	-
29-I	Yes	200	2343.1	1931	112.2	-	124.2	127.4	132.3	133.2	134.1	-	-	-	-	-
29-I	No	200	2335.8	1951	-	-	-	-	-	-	132.8	141.7	147.2	150.9	151.5	151.3
29-N	No	219	2376.9	1947	-	-	169.2	-	176.9	180.7	183.5	188.1	193.7	-	199.4	198.1
30-B	No	195	2355.6	1947	-	-	164.7	167.3	172.3	-	182.9/	-	-	-	-	-
30-H	No	225	2347.8	1950	-	-	-	-	-	163.7	166.8	173.1	176.5	180.4	179.9	-
31-D	Yes	300	2437.8	1948	-	-	-	232.9	236.5	236.8	239.2	241.1	243.4	246.6	250.3	253.1
31-I	No	242	2465.4	1947	-	-	224.8	225.1	-	226.5	226.4	227.9	228.9	231.2	229.4	233.1
32-M	Yes	-	2468.0	1948	-	-	-	216.9	-	-	217.0	219.7	-	223.0	223.9	224.2
33-B	No	-	2293.8	1907	28.4/	-	-	-	-	-	-	-	-	-	-	-
33-B	Yes	151	2285.3	1949	-	-	-	-	49.7	53.1	56.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface — First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
									Township 13 South, Range 13 East (continued)							
33-I	Yes	175	2297.6	1946	34.2	-	36.6	40.5	44.7	49.8	53.4	59.3	64.5	70.2	72.1	71.8
33-J	No	-	2303.3	1948	-	-	-	56.0	62.4	65.8	68.3	75.5	80.8	85.8	87.8	86.6
33-M	No	-	2393.5	1947	-	-	144.5	148.0	151.3	155.4	158.9/	-	-	-	-	-
33-N	No	-	2363.8	1949	-	-	-	-	122.1	126.5	129.7	136.0	-	146.9	149.5	-
33-P	No	-	2298.0	1953	-	-	-	-	-	-	-	-	58.6	64.8	67.8	67.0
34-A	Yes	234	2308.7	1948	-	-	-	52.3	54.7	64.3	66.9	68.9	73.4	79.3	80.3	78.6
34-B	No	-	2293.3	1908	19.3/	-	-	-	-	-	-	-	-	-	-	-
34-C	Yes	201	2291.4	1926	26.1	-	34.9	40.6	44.7	48.8	52.3	59.3	64.4	69.4	73.6	70.6
34-O	Yes	310	2305.1	1952	-	-	-	-	-	-	-	58.1	62.7	68.3	70.8	70.8
35-C	Yes	228	2319.3	1940	-	44.0	-	61.1	60.1	74.7	-	77.1	86.2	91.9	94.6	87.6
35-D	No	-	2320.6	1908	42.1/	-	-	-	-	-	-	-	-	-	-	-
35-F	Yes	228	2328.5	1946	59.8	-	-	72.4	70.5	-	74.3	80.2	89.7	-	-	-
35-M	Yes	130	2318.6	1931	36.9	36.6	-	42.6	43.3/	-	-	-	-	-	-	-
35-M	Yes	500	2316.1	1948	-	-	-	53.4	47.5	58.0	60.7	-	69.0	75.0	78.6	79.4
36-E	No	87	2342.4	1946	73.2	-	78.6	69.4	69.9	76.2	78.6/	83.4	85.7	93.9/	-	-
36-G	No	157	2351.5	1946	57.2	-	63.1	64.3	67.9	70.6	74.3	78.8	80.2	85.1	88.5	90.6
36-J	Yes	250	2378.5	1946	77.8	-	81.2	-	-	-	100.7	103.3	-	-	-	-
36-M	No	-	2356.1	1946	63.5	-	57.8	58.3	58.8	56.9/	-	-	-	-	-	-
36-P	Yes	375	2393.9	1950	-	-	-	-	-	102.2	104.9	110.0	-	115.9	119.3	121.7
									Township 13 South, Range 14 East							
1-M	Yes	170	3029.7	1930	139.2	-	158.4	-	-	153.5.	-	161.7	167.1	-	-	-
5-D	No	253	2770.4	1947	-	-	135.6	-	-	137.7	-	-	-	-	-	-
11-F	Yes	640	2903.1	1931	390.0	-	392.2	-	-	392.0	392.2	392.1	-	392.2	-	-
13-D	Yes	335	2768.7	1930	264.1	-	262.5	262.6	262.5	262.4	-	262.3	262.5	262.5	262.6	262.6
18-L	Yes	260	2443.7	1930	160.7	-	173.1	-	-	185.9	190.1	194.4	196.4/	-	-	-
19-D	No	-	2329.7	1909	17.2/	-	-	-	-	-	-	-	-	-	-	-
19-D	No	160	2346.5	1946	55.8	-	58.0	-	71.5	77.1	81.8	86.1	86.4	91.5	94.9	97.4
19-K	No	-	2332.8	1946	32.8	-	-	36.3	37.4	44.1	48.6	44.2	-	-	65.2	62.9
19-L	No	-	2325.5	1946	32.0	-	35.3	42.4	42.7	49.4	52.5	46.7	56.5	62.0	65.8	67.7
19-O	Yes	300	2340.3	1946	29.7	-	31.7	36.4	37.6	41.0	47.9	42.9	47.8	53.9	57.0	58.1
19-P	Yes	163	2345.4	1908	8.0	25.9	30.9	32.7	33.7	36.9	42.8	42.1	43.0	50.2	53.0	53.7
20-D	Yes	180	2404.7	1929	85.7	-	94.7	-	-	-	-	-	-	-	-	-
20-L	Yes	137	2360.1	1946	44.6	-	47.1	49.9	49.6	53.6	59.4	48.0	56.4	66.8	69.9	71.2
20-M	No	-	2349.4	1954	-	-	-	-	-	-	-	-	-	52.0	53.8	55.3
20-N	Yes	140	2356.3	1954	-	-	-	-	-	-	-	-	-	44.8	46.3	50.9

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface — First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
									Township 13 South, Range 14 East (continued)							
21-M	No	-	2369.3	1952	-	-	-	-	-	-	-	28.4	-	41.5	42.7	42.5
21-N	No	-	2371.8	1946	27.2	-	30.5	29.8	30.9	36.4	-	28.1	38.8	42.7	42.6	43.1
21-O	No	-	2392.6	1954	-	-	-	-	-	-	-	-	-	55.4	55.5/	-
21-P	No	-	2419.4	1950	-	-	-	-	-	76.5	79.0	66.8	73.5	79.4	80.0	80.8
22-A	No	250	2625.2	1952	-	-	-	-	-	-	-	175.4	-	176.2	175.6	180.5
22-I	Yes	266	2554.6	1929	168.0	-	-	147.3	147.2	147.7	148.3	147.9	148.7	150.0	149.5	149.9
22-L	Yes	200	2501.5	1949	-	-	-	-	160.2	157.9	161.8	163.0	156.6	165.9	164.2	164.7
22-M	Yes	300	2452.1	1929	106.0	-	104.8	106.5	106.0	107.0	109.6	106.0	105.7/	-	-	-
23-D	Yes	243	2624.7	1930	180.0	-	177.5	-	177.4	178.2	178.3	-	-	-	179.3	179.8
23-M	No	-	2510.3	1951	-	-	-	-	-	-	120.8	-	117.8	120.8	119.4	-
25-I	No	-	2455.5	1946	19.5	-	18.5	20.2	15.6	19.8	21.2	15.2	17.6	18.2	-	-
25-K	Yes	100	2441.5	1950	-	-	-	-	-	13.4	14.6	7.2	11.8	12.0	14.3	14.2
25-M	No	-	2434.8	1947	-	-	16.6	-	10.7	17.8	18.6	10.3	19.8	16.4	19.6	17.2
25-N	No	-	2440.5	1907	13.3/	-	-	-	-	-	-	-	-	-	-	-
25-N	Yes	160	2439.9	1947	-	-	12.8	13.9	9.3	14.2	14.9	8.3	12.3	12.0	15.3	14.7
25-P	No	16	2441.4	1940	-	11.3-	10.6	11.7/	-	-	-	-	-	-	-	-
25-P	No	-	2455.5	1946	19.4	-	18.5	20.2	15.6	19.8	21.2	15.1	17.6	18.2	20.9	-
26-I	No	-	2430.6	1946	22.1	-	21.7	22.8	16.3	23.5	22.8	12.0	19.8	18.6	-	24.2
26-N	No	-	2419.4	1906	12.2/	-	-	-	-	-	-	-	-	-	-	-
26-O	No	-	2425.5	1946	19.1	-	18.5	19.9	11.0	20.5	23.2	10.6	20.9	-	-	23.6
27-C	No	100	2405.1	1947	-	-	30.5	34.1	20.5	34.6	37.5	14.0	32.7	27.8	37.6	39.1
27-D	No	-	2414.3	1950	-	-	-	-	-	59.3	60.1	42.1	56.9	51.8	60.3	61.2
27-E	No	-	2395.3	1946	30.7	-	30.4	35.6	27.2/	-	-	-	-	-	-	-
27-H	Yes	91	2435.4	1938	35.0	-	-	-	-	-	-	-	-	39.7	43.5	45.3
27-M	No	-	2386.6	1909	13.6/	-	-	-	-	-	-	-	-	-	-	-
27-M	No	105	2405.1	1946	37.9	-	39.9	45.2	40.5	48.1	53.4	35.1	51.6	54.6	58.2	58.7
27-N	Yes	194	2415.9	1946	42.3	-	45.5	51.3	43.1	54.5	-	39.9	56.9	59.1	63.0	64.8
27-P	Yes	290	2410.3	1906	8.5	-	23.6	29.7	14.5	31.1	35.9	11.4	30.5	22.4	33.9	39.8
28-A	Yes	175	2411.9	1946	55.2	-	55.6	61.0	64.2	62.5	68.3	49.6	61.8	60.6	69.0	70.8
28-B	Yes	140	2380.0	1946	30.0	-	32.3	36.1	29.2	37.9	40.8	25.6	39.7	46.4	45.7	46.7

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface												
				First record												
				Year	Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
Township 13 South, Range 14 East (continued)																
28-C	No	-	2371.0	1929	22.4	-	24.2	29.6	29.2	37.2	-	20.0	-	-	-	-
28-F	No	-	2378.0	1952	-	-	-	-	-	-	-	23.0	39.3	44.9	46.2	46.9
28-G	Yes	120	2382.8	1946	28.3	-	29.4	32.8	29.5	38.0	40.5	18.8	38.5	40.8	44.2	-
28-I	No	-	2392.2	1946	30.0	-	33.3	37.2	30.4	36.1	36.1	19.1	35.1	33.9	35.0	34.7
28-J	No	-	-	1909	13.9/	-	-	-	-	-	-	-	-	-	-	-
28-K	Yes	236	2400.0	1933	31.6	-	47.8	49.7	45.7	45.7	56.9	38.5	57.2	60.8	56.1	-
28-L	Yes	128	2389.4	1946	38.4	-	41.0	42.8	42.6	47.2	50.7	40.3	51.6	55.8	58.3	59.9
28-M	No	-	2401.0	1953	-	-	-	-	-	-	-	-	63.5	68.9	70.5	72.0
28-N	No	100	2405.0	1947	-	-	55.5	57.2	56.3	60.7	-	-	65.1	-	72.2	-
28-O	No	-	2401.8	1953	-	-	-	-	-	-	-	-	59.6	63.4	66.1	67.3
28-P	Yes	221	2412.4	1948	-	-	-	55.6	52.2	58.3	63.7	53.5	-	69.2	71.8	71.8
29-A	Yes	94	2365.6	1946	24.9	-	28.2	32.0	29.9	33.3	-	24.2	36.1	-	43.2	43.6
29-B	No	-	2360.9	1946	25.5	-	27.4	30.1	30.0	32.9	-	29.3	-	-	-	-
29-D	Yes	78	2360.6	1946	39.6	-	42.8	46.0	46.5	49.1	-	50.2	53.2	59.6	63.9/	63.0
29-F	No	-	2359.3	1907	14.7/	-	-	-	-	-	-	-	-	-	-	-
29-F	No	-	2360.5	1932	13.9	25.1-	36.0	-	-	-	-	-	-	-	-	-
29-M	No	-	2390.3	1949	-	-	-	-	69.3	-	73.9	75.6	76.8	-	84.5	-
29-P	No	-	2397.6	1952	-	-	-	-	-	-	-	63.5	69.0	-	76.3	72.9
30-B	No	-	2347.8	1946	36.8	-	41.1	44.2	46.1	51.0	-	53.3	57.7	64.1	67.0	68.5
30-D	Yes	125	2342.8	1931	30.8	-	48.0	50.8	53.0	57.1	60.5	62.8	-	66.7/	-	-
30-M	No	-	2358.2	1907	40.0/	-	-	-	-	-	-	-	-	-	-	-
30-M	Yes	200	2356.0	1945	52.0	-	57.6	59.0	62.3	63.7	71.4	73.4	73.9	78.4	83.2	85.3
31-E	No	-	2356.6	1907	46.7/	-	-	-	-	-	-	-	-	-	-	-
31-F	No	-	2391.1	1946	76.1	-	78.8	-	84.4	89.5	93.3	96.3	97.4	102.8	104.6	105.8
31-G	No	-	2380.8	1950	-	-	-	-	-	67.7	71.4	73.5	78.7	82.6	83.1	83.3
31-J	Yes	390	2400.4	1950	-	-	-	-	-	82.5	-	89.8	89.5	95.7	97.1	97.9
31-K	No	-	2394.2	1951	-	-	-	-	-	-	92.8	97.7	103.0	109.8	109.6	105.0
32-D	No	-	2385.5	1947	-	-	59.3	-	65.4	68.0	70.2	71.2	73.0	78.3	79.8	81.2
32-F	Yes	319	2399.6	1952	-	-	-	-	-	-	-	67.2	71.7	76.5	78.2	79.4
32-J	No	119	2405.2	1947	-	-	63.6	64.8	67.6	72.6	73.5	75.1	76.7	81.6	83.6	-

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface: First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
									Township 13 South, Range 14 East (continued)							
33-E	Yes	246	2408.4	1949	-	-	-	-	62.3	67.4	69.8	67.1	71.5	76.7	78.8	80.2
33-H	No	243	2424.4	1949	-	-	-	-	64.0	67.5	71.2	68.7	72.7	78.8	81.2	82.7
33-K	Yes	114	2416.8	1946	59.6	-	60.1	62.8	64.9	66.7	-	69.8	72.0	76.6	78.7	80.2
33-M	No	-	2417.8	1908	-	-	-	-	-	-	-	-	-	-	-	-
33-M	Yes	271	2426.2	1952	-	-	-	-	-	-	-	82.1	85.2	89.5	92.7	93.6
33-N	Yes	245	2429.7	1949	-	-	-	-	79.2	79.6	82.2	84.1	87.0	90.8	96.0	94.2
34-C	No	137	2431.6	1953	-	-	-	-	-	-	-	-	70.1	71.0	73.2	76.3
34-F	No	105	2432.6	1947	-	-	60.5	61.4	61.5	65.2	68.7	65.5	69.6	75.3	75.0	77.8
34-K	Yes	239	2442.2	1949	-	-	-	-	70.7	73.1	-	75.1	79.1	83.8	86.1	88.2
34-O	No	165	2452.6	1952	-	-	-	-	-	-	-	83.1	86.5	91.2	92.2	94.5
35-A	No	-	2446.4	1906	34.1/	-	-	-	-	-	-	-	-	-	-	-
35-A	No	-	2438.8	1946	33.8	-	32.0	35.8	34.2	-	-	30.4/	-	-	-	-
35-B	No	-	2438.6	1954	-	-	-	-	-	-	-	-	-	53.0	49.0	50.5
35-C	No	-	2430.2	1947	-	-	36.3	39.3	34.2	40.8	46.6	33.1	50.3	52.1	54.8	52.5
35-D	No	-	2320.6	1908	42.1/	-	-	-	-	-	-	-	-	-	-	-
35-D	No	165	2424.1	1946	35.0	-	35.5	39.7	29.9	43.1	-	27.6	46.4	47.1	52.0	-
35-H	No	-	2449.1	1946	45.0	-	45.8	48.6	48.6	51.1	55.1	49.0	57.2	60.3	59.9	61.5
35-N	No	-	2455.7	1908	58.4/	-	-	-	-	-	-	-	-	-	-	-
35-O	Yes	208	2465.7	1946	68.9	-	-	72.4	73.9	76.3	-	79.0	85.7	90.9	91.3	91.3
36-D	Yes	244	2453.8	1948	-	-	-	46.1	41.5	48.2	-	39.7	53.4	60.1	55.2	56.1
36-E	No	-	2453.8	1907	40.1/	-	-	-	-	-	-	-	-	-	-	-
36-F	No	-	2477.9	1951	-	-	-	-	-	-	76.0	75.1	79.4	83.0	83.3	84.5
36-J	No	-	2490.4	1952	-	-	-	-	-	-	-	87.2	-	-	94.9	96.5
36-M	No	-	2483.5	1955	-	-	-	-	-	-	-	-	-	-	98.6	101.0
36-N	No	206	2486.9	1951	-	-	-	-	-	-	87.4	88.4	91.6	96.0	98.5	98.9
36-P	No	-	2487.6	1952	-	-	-	-	-	-	-	83.6	83.2	-	84.1	86.0
									Township 13 South, Range 15 East							
17-E	Yes	112	2687.9	1947	-	-	78.8	-	-	-	-	84.4	83.6	-	-	84.0
18-G	No	261	2788.7	1949	-	-	-	-	205.5	202.0	172.4	160.5	158.9/	-	-	-
19-N	Yes	304	2623.5	1930	146.5	-	147.4	147.5	148.3	148.4	153.1	148.9	149.5	149.1	151.7	152.3
20-G	Yes	134	2598.1	1947	-	-	47.7	49.6	-	52.2	-	54.5	55.8	59.2	58.0	57.6
21-I	No	-	2596.2	1951	-	-	-	-	-	-	74.4	-	-	-	89.0	88.4

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface: First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
										Township 13 South, Range 15 East (continued)						
22-G	Yes	216	2605.0	1930	30.0	-	47.9	48.7	49.5	51.3	51.7	52.2	53.0	53.2	54.8	55.5
22-M	No	-	2545.6	1952	-	-	-	-	-	-	-	10.8	11.0	14.8	11.4	14.2
26-O	Yes	204	2654.3	1947	-	-	115.0	114.5	113.1	114.0	-	-	-	-	-	-
27-A	Yes	217	2595.0	1950	-	-	-	-	-	59.5	60.0	60.7	61.4	61.1	62.4	59.2
27-C	Yes	62	2570.2	1930	42.8	-	46.0	47.0	-	50.9	48.2	50.8	53.8	48.9	50.8	54.3
27-D	No	-	2557.1	1952	-	-	-	-	-	-	-	25.1	25.4	27.0	25.7	31.4
27-P	Yes	174	2586.4	1950	-	-	-	-	-	66.7	67.3	67.5	66.6	68.0	-	68.2
28-O	No	21	2513.2	1946	7.5	-	9.5	20.2	4.9	9.4	19.0	4.9	6.4	8.6	8.0	-
29-D	Yes	135	2536.8	1930	53.0	-	53.4	54.0	54.8	-	-	-	56.8	-	-	-
29-F	Yes	129	2565.5	1930	82.6	-	84.5	85.3	85.9	86.5	88.2	87.9	-	-	87.4	85.2
29-G	Yes	202	2583.9	1948	-	-	-	102.0	103.7	104.4	105.4	104.4	104.3	105.3	105.0	105.3
29-J	No	-	2555.4	1955	-	-	-	-	-	-	-	-	-	-	68.9	70.3
29-N	No	-	2484.8	1907	6.2/	-	-	-	-	-	-	-	-	-	-	-
30-H	No	153	2535.0	1947	-	-	66.8	68.3	69.1	70.4	70.9	70.1	69.8	71.0	69.6	-
30-O	No	-	2474.8	1946	30.0	-	29.6	32.9	26.1	30.7	31.1	26.5	27.2	-	-	-
30-P	No	65	2476.1	1946	13.4	-	12.7	16.0	11.9	-	-	12.1	13.0	13.4	15.9	16.5
31-A	No	-	2469.0	1907	9.7/	-	-	-	-	-	-	-	-	-	-	-
31-B	Yes	195	2470.1	1931	8.8	-	10.5	13.7	10.4	13.9	15.0	10.6	11.3	12.5	13.9	15.0
31-C	No	-	2469.2	1906	27.0/	-	-	-	-	-	-	-	-	-	-	-
31-H	Yes	25	2477.9	1946	13.3	-	-	16.3	11.8	17.1	17.2	10.4	11.7	13.1	15.5	17.1
31-J	Yes	86	2493.4	1946	50.6	-	50.9	53.6	56.2	56.1	59.1	59.3	59.9	62.5	62.8	64.9
32-A	No	-	2493.2	1907	6.0/	-	-	-	-	-	-	-	-	-	-	-
32-B	No	70	2494.0	1932	10.7	16.0	16.6	20.6	11.9	20.8	-	11.6	15.7	-	-	-
32-C	No	-	2472.1	1933	0.6	3.8	5.3	10.3	1.4	9.4	-	1.2	-	-	-	-
32-E	No	-	2494.5	1907	27.7/	-	-	-	-	-	-	-	-	-	-	-
32-E	No	94	2505.6	1947	-	-	39.6	42.5	38.9	42.3	44.5	38.5	38.8	-	41.9	42.9
32-G	No	105	2491.4	1933	7.4	11.6	13.4	18.0	10.2	17.7	20.5	9.9	13.9	-	18.5	20.5
32-P	No	28	2505.4	1946	19.2	-	20.0	22.6	20.1	22.9	24.2	18.8	21.7	22.4	24.2	24.9
33-A	No	-	2513.6	1946	15.8	-	12.4	-	11.7	15.6	-	-	-	-	-	-
33-C	No	-	2509.8	1946	13.1	-	12.7	19.3	8.8	17.1	22.6	12.0	13.9	15.0	15.1	21.4

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface: First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
									Township 13 South, Range 15 East (continued)							
33-F	No	-	2505.6	1954	-	-	-	-	-	-	-	-	-	14.9	17.1	-
33-K	No	-	2512.6	1954	-	-	-	-	-	-	-	-	-	22.0	24.2	24.4
34-E	No	167	2560.3	1950	-	-	-	-	-	43.0*	50.2	48.5	49.3	48.0	50.3	50.3
34-H	No	-	2621.5	1955	-	-	-	-	-	-	-	-	-	-	100.6	100.5
34-K	No	165	2535.2	1948	-	-	-	22.5	22.9	-	23.7	20.5	22.7	23.1	24.8	24.0
34-P	No	110	2520.8	1953	-	-	-	-	-	-	-	-	26.0	24.3	26.3	26.6
35-C	Yes	277	2700.3	1930	161.7	-	-	-	170.8	171.8	172.8	173.6	170.7	171.6	172.5	172.6
35-F	Yes	227	2626.4	1948	-	-	-	96.3	97.2	98.5	99.2	99.3	96.2	98.8	99.5	100.6
35-K	Yes	94	2613.7	1946	83.3	-	84.7	85.8	-	-	-	87.6	85.2	88.1	88.7	88.5
35-P	No	-	2590.7	1946	57.6	-	59.0	60.0	61.2	62.5	-	-	-	-	-	-
36-A	No	-	2628.3	1949	-	-	-	-	38.2	39.6	42.0	16.2/	-	-	-	-
36-C	No	200	2659.3	1949	-	-	-	-	90.6	90.7	90.7	91.0	90.7	90.8	90.7	90.7
									Township 13 South, Range 16 East							
19-I	No	-	2695.9	1953	-	-	-	-	-	-	-	-	17.6	15.7	-	30.9
29-M	Yes	402	2735.5	1950	-	-	-	-	-	142.7	150.6	153.1	143.4	157.7	154.3	148.1
30-J	Yes	27	2655.4	1915	20.0	-	-	-	20.0	26.2	26.6	11.4	21.8	15.3	25.7	26.3
30-O	No	-	2645.2	1949	-	-	-	-	17.7	23.6	24.4	8.3	21.6/	-	-	-
32-J	No	400	2689.1	1953	-	-	-	-	-	-	-	-	87.7	89.0	102.3	-
32-L	No	-	2663.1	1948	-	-	-	59.2	-	-	-	61.9	62.4	-	-	-
33-H	No	-	2846.2	1952	-	-	16.7	17.0	-	-	-	15.6	16.5	17.4	-	-
34-L	Yes	240	2798.6	1955	-	-	-	-	-	-	-	-	-	-	57.0	52.1
34-M	Yes	241	2787.8	1947	-	-	58.1	57.4	-	-	-	52.0	61.2	62.5	-	-
34-N	No	240	2797.3	1947	-	-	50.0	50.0	-	-	-	49.2	-	-	-	-
									Township 14 South, Range 13 East							
1-D	No	-	2364.5	1931	57.2	60.7	-	-	-	-	-	-	-	-	-	-
1-E	Yes	302	2371.9	1954	-	-	-	-	-	-	-	-	-	101.3	103.0	102.6
1-H	No	-	2412.9	1907	80.1/	-	-	-	-	-	-	-	-	-	-	-
1-I	Yes	350	2395.6	1945	82.0	-	85.1	89.6	92.2	95.4	100.5	108.0	103.3	111.5	112.3	113.7
2-M	No	-	2327.4	1946	34.3	-	34.4	35.6	36.2	41.8	41.7	41.0	62.7	69.4	68.4	-

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
				Depth to water in feet from measuring point, at approximate ground surface												
								Township 14 South, Range 13 East (continued)								
2-N	Yes	400	2332.8	1913	23.9	-	39.7	43.1	42.8	49.3	53.4	59.6	63.8	70.7	60.6	68.8
3-D	No	-	2301.4	1946	32.5	-	31.3	34.7	38.3	43.7	47.2	-	-	-	-	-
3-G	No	-	2317.6	1949	-	-	-	-	41.1	48.7	51.3	55.0	60.7	66.9	68.8	-
3-K	No	-	2328.3	1948	-	-	-	49.0	50.5	-	-	64.9	69.4	76.4	78.0	77.4
3-O	No	-	2338.5	1907	36.6/	-	-	-	-	-	-	-	-	-	-	-
3-P	No	-	2331.5	1908	27.5/	-	-	-	-	-	-	-	-	-	-	-
4-G	No	-	2358.2	1931	85.2	-	93.6	-	-	-	-	112.9	118.0	123.7	127.1	126.3
5-D	No	405	2477.9	1953	-	-	-	-	-	-	-	-	222.5	225.0	225.3	226.5
10-G	Yes	151	2344.9	1933	40.0	-	-	-	-	-	-	-	-	81.0	79.1	77.0
10-H	No	-	2342.2	1908	31.8/	-	-	-	-	-	-	-	-	-	-	-
10-I	Yes	100	2343.9	1947	-	-	47.2	49.6	-	56.6	60.2	65.1	70.8	77.9	77.1	76.2
11-D	No	230	2334.9	1946	45.6	-	44.6	45.1	47.4	-	-	62.4	67.7	74.8	75.4	73.1
11-E	No	-	2341.0	1947	-	-	39.0	44.3	46.8	52.2	-	60.9	67.1	74.3	73.5	71.5
11-G	Yes	250	2341.7	1953	-	-	-	-	-	-	-	-	60.2	68.7	68.0	-
11-G	No	-	2334.7	1908	17.2/	-	-	-	-	-	-	-	-	-	-	-
11-J	No	-	2340.6	1947	-	-	30.0	40.8	30.7	-	-	-	33.8	-	-	-
11-K	No	40	2333.0	1940	-	-	-	-	-	27.2	27.5	28.4	29.5	71.2	65.9	-
11-P	No	129	2345.5	1949	-	-	-	-	27.4	26.8	28.3	33.9	37.8	37.6	35.9	33.7
12-E	Yes	250	2352.0	1947	-	-	39.8	42.6	-	44.9	47.0	49.8	51.0	58.3	58.8	58.8
12-J	Yes	730	2369.1	1953	-	-	-	-	-	-	-	-	68.8	-	74.3	-
12-N	Yes	315	2383.3	1946	50.0	-	52.1	54.6	-	58.4	60.0	61.8	64.0	69.1	68.3	66.9
13-L	Yes	274	2367.4	1950	-	-	-	-	-	30.9	34.0	-	38.0	39.6	35.5	34.6
14-D	No	-	2351.9	1908	31.8/	-	-	-	-	-	-	-	-	-	-	-
14-F	No	38	2355.2	1905	-	-	-	-	-	30.9	33.0	34.1	-	-	-	-
14-H	No	91	2348.2	1955	-	-	-	-	-	-	-	-	-	-	28.7	17.7
14-J	No	-	2356.0	1908	19.9/	-	-	-	-	-	-	-	-	-	-	-
14-K	No	-	2359.0	1946	25.5	-	25.3	27.2	27.3	28.7	29.0	-	-	-	-	-
14-N	No	-	2363.9	1955	-	-	-	-	-	-	-	-	-	-	29.8	-
14-P	No	-	2366.3	1946	25.0	-	23.1	26.1	28.0	28.4	28.0	30.0	32.0	34.7	30.0	29.1
22-C	Yes	169	2410.3	1949	-	-	-	-	66.5	64.5	-	65.4	-	68.5	64.5	63.6

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface: First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
								Township 14 South, Range 13 East (continued)								
22-H	No	-	2376.8	1908	14.9/	-	-	-	-	-	-	-	-	-	-	-
22-H	No	164	2376.7	1929	22.7	-	23.9	27.7	28.7	31.4	33.3	32.3	35.9	36.2	33.2	30.9
22-I	No	90	2382.3	1929	25.3	17.8	-	30.1	32.1	33.8	35.2	35.6	39.1	-	36.7	-
22-L	No	108	2438.0	1947	-	-	83.6	86.7	89.0	90.1	91.3	92.3	95.4	96.4	92.8	90.0
23-C	Yes	70	2372.0	1929	-	-	-	-	26.1	28.1	30.3	30.7	36.1	38.2	32.7	31.3
23-F	No	-	2377.3	1947	-	-	25.2	28.1	29.6	31.4	32.7	33.6	35.8	37.4	33.3	32.2
23-G	No	-	2368.2	1952	-	-	-	-	-	-	-	27.3	32.2	36.4	29.7	28.6
23-G	No	-	2374.3	1946	24.9	-	22.4	25.1	27.2	28.3	29.8	30.9	34.2	35.9	31.7	29.7
23-K	No	-	2377.6	1909	15.5/	-	-	-	-	-	-	-	-	-	-	-
23-O	Yes	240	2387.0	1948	-	-	-	31.1	-	-	38.5	-	39.2	40.6	37.4	34.3
24-E	No	-	2393.4	1908	27.0/	-	-	-	-	-	-	-	-	-	-	-
24-I	No	300	2439.8	1949	-	-	-	-	85.2	89.0	92.2	93.7	97.6	97.9	99.3	100.3
24-J	No	-	2422.7	1955	-	-	-	-	-	-	-	-	-	-	71.0	71.0
25-A	Yes	411	2447.1	1948	-	-	-	83.7	-	82.0	84.7	86.0	91.0	89.9	88.6	84.2
25-G	No	-	2440.5	1946	59.5	-	59.5	60.5	61.8	62.1	63.0	64.0	64.7	-	-	-
25-I	No	-	2462.0	1947	-	-	71.6	72.0	73.8	74.5	76.8	79.7	-	84.0	83.8	84.6
25-L	Yes	250	2430.1	1949	-	-	-	-	72.3	70.8	-	72.6	-	78.6	75.6	69.6
25-N	Yes	242	2453.2	1930	60.0	-	-	-	-	-	84.8	86.3	-	90.4/	-	-
25-P	Yes	500	2460.2	1939	59.0	-	-	-	-	-	-	-	100.4	103.7	99.3	-
26-B	No	-	2390.9	1930	21.9	21.3	29.0	-	32.8	35.3	37.7	36.4	40.5	40.7	37.0	33.1
26-D	Yes	130	2388.2	1953	-	-	-	-	-	-	-	-	38.9	39.8	36.3	32.8
26-G	No	280	2397.7	1930	23.0	24.9	33.1	-	36.2	38.6	40.5	40.3	44.0	44.4	42.6	33.7
26-M	Yes	63	2409.3	1913	22.6	29.5	39.5	42.0	42.6	46.5	-	48.0	51.1	53.3	48.9	43.0
27-A	No	40	2387.9	1946	30.0	-	29.0	28.9	33.3	35.2/	-	-	-	-	-	-
27-G	No	104	2405.7	1946	41.3	-	41.6	46.9	44.8	47.6	48.5	48.8	52.0	52.8	49.3	45.0
27-H	Yes	120	2400.6	1929	11.1	-	34.6	-	39.4	-	-	-	-	-	-	-
27-H	Yes	220	2398.7	1950	-	-	-	-	-	40.5	41.4	41.2	45.0	46.1	42.4	38.0
27-O	Yes	103	2411.1	1930	30.4	-	-	44.1	-	-	-	-	-	-	-	.
34-A	Yes	149	2411.0	1952	-	-	-	-	-	-	-	48.8	52.1	53.3	49.6	43.6
34-B	No	-	2411.3	1955	-	-	-	-	-	-	-	-	-	-	52.0	42.5

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface												
				First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
Township 14 South, Range 13 East (continued)																
34-B	No	-	2417.4	1915	22.8	33.9/	-	-	-	-	-	-	-	-	-	-
34-F	No	-	2417.1	1907	22.7/	-	-	-	-	-	-	-	-	-	-	-
34-G	No	-	2414.9	1955	-	-	-	-	-	-	-	-	-	-	52.0	45.5
34-H	No	-	2418.6	1913	22.3	-	31.4	-	-	-	-	53.2	56.0	58.6	53.3	48.3
34-I	No	-	2422.5	1946	51.0	-	46.7	54.1	48.7	54.1	54.3	54.3	55.6	58.8	60.1	-
34-O	Yes	144	2429.2	1943	42.3	-	-	51.3	51.5	-	56.8	60.8	61.0	64.8	59.6	53.0
34-P	Yes	130	2428.6	1943	42.9	-	45.3	-	50.8	-	55.8	59.5	60.7	63.5	58.6	51.8
35-E	Yes	122	2414.5	1913	19.4	28.8	-	-	-	-	-	-	-	-	-	-
35-F	No	154	2419.5	1931	30.7	33.2	44.5	-	-	-	-	-	-	-	-	-
35-H	Yes	300	2444.3	1949	-	-	-	-	70.0	74.4	75.0	76.5	79.6	81.2	77.8	70.5
35-K	No	-	2422.5	1931	31.5	33.8	46.1	-	-	54.5	-	55.5	57.0	59.1	55.9	49.0
35-L	No	-	2417.6	1949	-	-	-	-	44.8	50.2	50.2	51.0	-	-	-	-
35-M	No	250	2423.8	1948	-	-	-	47.1	47.6	-	52.2	55.0	-	58.9	55.3	48.0
35-N	No	-	2428.2	1931	31.5	33.5	46.1	48.7	49.7	54.1	54.8	56.9	61.0	60.6	-	-
35-O	No	-	2449.4	1907	36.6/	-	-	-	-	-	-	-	-	-	-	-
35-O	Yes	255	2443.6	1948	-	-	-	72.5	-	70.5	-	72.3	76.1	77.3	73.7	66.8
35-O	Yes	159	2451.8	1947	-	-	45.4	47.0	48.1	49.5	-	52.3	54.2/	-	-	50.3
36-A	No	-	2461.4	1907	64.3/	-	-	-	-	-	-	-	-	-	-	-
36-G	Yes	240	2465.8	1949	-	-	-	-	86.6	90.0	92.1	94.4	-	99.4	99.1	92.5
36-K	No	300	2464.0	1949	-	-	-	-	72.7	78.1	82.2	84.4	87.2	89.8	86.5	80.1
36-M	Yes	250	2464.8	1949	-	-	-	-	79.5	79.8	79.2	82.5	85.2	85.9	86.1	76.5
36-O	Yes	304	2488.1	1943	88.0	-	-	-	-	102.2	-	112.6	122.0	111.7	110.2	102.8
Township 14 South, Range 14 East																
1-F	No	-	2500.3	1908	86.9	-	-	-	-	-	-	-	-	-	-	-
1-F	No	-	2497.7	1946	91.7	-	92.1	93.6	95.8	98.1	99.5	-	103.1	106.3	108.5	111.2
1-H	No	157	2520.8	1947	-	-	106.7	107.7	109.5	111.0	109.2	111.2	116.8	119.7	122.4	123.6
1-P	Yes	314	2530.4	1946	114.8	-	116.2	117.4	119.2	120.7	122.9	124.6	126.8	129.4	131.9	134.3
2-E	No	-	2480.9	1946	89.9	-	92.5	-	94.7	96.9	-	101.3	102.9	107.2	109.5	112.0

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface: First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
Township 14 South, Range 14 East (continued)																
2-G	No	-	2481.0	1946	83.3	-	84.7	86.4	88.8	90.6	93.6	95.2	98.0/	-	-	-
2-G	Yes	300	2483.7	1952	-	-	-	-	-	-	-	96.2	98.1	-	104.4	106.7
2-H	No	-	2489.6	1907	82.7/	-	-	-	-	-	-	-	-	-	-	-
2-I	Yes	185	2495.3	1947	92.9	-	94.0	-	97.7	99.5	102.3	104.5	-	109.5	115.0	115.5
2-O	No	320	2499.7	1949	-	-	-	-	105.0	106.8	108.5	111.8	-	117.0	119.8	122.4
3-A	No	170	2460.4	1947	-	-	76.8	78.9	81.2	83.5	86.7	-	-	95.4	96.1	-
3-H	No	-	2471.1	1949	-	-	-	-	91.2	94.6	96.4	98.0	99.4	104.5	106.7	109.0
3-I	No	-	2477.9	1952	-	-	-	-	-	-	-	103.6	-	110.1	112.3	114.9
4-A	No	-	2448.8	1950	-	-	-	-	-	85.5	89.3	89.5	91.0	96.5	98.3	100.2
4-B	No	-	2447.4	1946	81.0	-	85.0	87.4	90.1	92.6	-	96.6	97.4	-	-	-
4-D	No	122	2436.3	1946	82.2	-	82.4	85.3	-	-	-	-	-	-	-	-
4-H	No	-	2474.5	1907	94.7/	-	-	-	-	-	-	-	-	-	-	-
4-J	No	-	2459.2	1955	-	-	-	-	-	-	-	-	-	-	111.9	114.0
4-N	No	-	2456.9	1949	-	-	-	-	102.8	103.1	106.1	107.6	-	-	115.3	121.8
5-B	No	-	2432.6	1907	70.1	-	-	-	-	-	-	-	-	-	-	-
5-H	No	-	2439.0	1952	-	-	-	-	-	-	-	101.2	102.6	106.9	109.1	110.4
5-I	No	-	2457.6	1950	-	-	-	-	-	117.1	118.7	121.2	-	-	127.6	129.4
5-O	Yes	248	2454.6	1945	107.0	-	-	-	116.8	-	121.7	122.0	128.2	128.7	128.0	130.3
5-O	No	-	2457.7	1907	94.4/	-	-	-	-	-	-	-	-	-	-	-
5-P	Yes	240	2469.4	1939	105.0	-	-	-	129.3	-	-	135.0	134.8	136.9	138.8	142.9
6-F	Yes	266	2434.2	1924	100.0	105.0	-	-	119.2	123.3	-	-	129.4	134.7	135.3	136.1
6-J	Yes	207	2448.9	1922	102.1	114.1	121.6	124.4	127.0	130.8	133.3	134.5	136.5	141.4	142.9	144.4
6-N	No	-	2432.4	1907	87.3/	-	-	-	-	-	-	-	-	-	-	-
7-B	Yes	500	2437.0	1937	99.6	102.6	113.1	117.1	119.7	123.9	118.8	-	-	-	141.1	-
7-C	No	-	2436.0	1907	86.5/	-	-	-	-	-	-	-	-	-	-	-
7-F	Yes	282	2424.3	1915	74.1	88.4	98.7	102.6	106.0	109.4	114.2	114.7	117.8	120.3	125.2	124.8
7-G	Yes	320	2427.1	1920	81.8	-	98.0	-	105.4	-	112.9	-	119.0	117.7	121.9	121.5
7-I	Yes	506	2431.8	1930	77.5	88.0	95.1	99.3	103.7	110.6	113.8	-	112.5	116.6	114.5	118.5
7-P	No	-	2437.4	1907	73.4	-	-	-	-	-	-	-	-	-	-	-
8-A	Yes	352	2485.5	1947	128.7	-	128.7	133.3	139.3	143.1	143.6	146.2	145.0	149.9	153.9	153.5

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface — First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
									Township 14 South, Range 14 East (continued)							
8-B	No	-	2485.0	1907	28.6/	-	-	-	-	-	-	-	-	-	-	-
8-C	Yes	510	2476.7	1921	111.0	-	-	149.1	152.9	157.3	151.9	151.2	156.6	158.1	161.0	161.6
9-B	Yes	339	2481.6	1955	-	-	-	-	-	-	-	-	-	-	136.7	137.7
9-E	Yes	351	2495.1	1928	113.5	-	128.3	132.0	135.8	140.8	143.5	143.9	143.7	-	-	157.4
9-E	No	-	2484.1	1946	124.5	-	122.0	126.9	130.5	135.2	135.8	137.7	138.0	-	147.1	149.2
9-I	No	302	2513.3	1949	-	-	-	-	136.5	-	143.3	144.2	148.4	152.1	155.3	158.3
9-N	No	-	2487.5	1907	101.2	-	-	-	-	-	-	-	-	-	-	-
10-C	No	-	2489.9	1955	-	-	-	-	-	-	-	-	-	-	136.7	139.1
10-G	No	-	2517.7	1949	-	-	-	-	131.9	135.4	-	-	142.9	148.0	150.5	-
10-I	No	-	2520.6	1907	118.4	-	-	-	-	-	-	-	-	-	-	-
10-L	Yes	323	2508.9	1951	-	-	-	-	-	-	138.3	135.4	138.1	142.1	141.9	147.5
10-M	Yes	187	2517.8	1930	-	-	-	132.1	134.1	137.5	140.3	142.5	145.4	147.9	152.4	155.3
10-O	Yes	307	2519.9	1949	-	-	-	-	132.6	135.5	140.2	140.5	143.6	147.8	151.1	151.5
11-I	No	-	2517.7	1953	-	-	-	-	-	-	-	-	142.9	147.5	150.5	-
11-M	Yes	320	2523.7	1950	-	-	-	-	-	132.8	137.4	141.1	-	144.9	148.1	151.6
11-O	No	-	2531.5	1946	128.1	-	129.0	129.8	133.8	134.8	137.2	139.8	142.4	146.4/	-	-
11-P	Yes	380	2541.4	1952	-	-	-	-	-	-	-	146.3	148.7	152.3	157.9	161.1
12-D	No	-	2514.8	1907	103.6	-	-	-	-	-	-	-	-	-	-	-
12-F	Yes	260	2541.7	1950	-	-	-	-	-	137.1	139.2	141.3	-	147.6	151.0	153.7
12-M	Yes	269	2567.2	1949	-	-	-	-	159.9	161.8	163.9	166.1	166.4	171.6	174.9	175.4
12-N	Yes	238	2566.4	1947	-	-	152.0	153.0	154.8	-	-	160.0	-	-	168.3	171.1
12-O	Yes	278	2585.6	1946	168.9	-	169.8	170.5	172.0	174.1	176.2	177.5	180.4	183.0	186.1	190.5
13-P	Yes	298	2604.1	1947	-	-	178.9	179.6	180.8	182.3	189.0	186.0	188.5	191.2	188.7	205.9
14-F	Yes	320	2562.7	1950	-	-	-	-	-	164.5	165.6	170.7	-	-	185.0	187.1
14-G	No	-	2570.4	1947	-	-	164.0	165.0	167.2	170.0	-	174.5	178.9	181.2	188.5	191.9
14-K	Yes	302	2564.5	1955	-	-	-	-	-	-	-	-	-	-	182.3	187.2
14-N	No	-	2562.8	1955	-	-	-	-	-	-	-	-	-	-	180.2	185.2
14-O	No	-	2564.8	1955	-	-	-	-	-	-	-	-	-	-	177.9	-
14-P	Yes	380	2578.0	1954	-	-	-	-	-	-	-	-	-	176.6	-	189.4
15-A	Yes	297	2531.7	1955	-	-	-	-	-	-	-	-	-	-	158.2	161.5

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface — First record Year	Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
Township 14 South, Range 14 East (continued)																
15-E	Yes	300	2514.8	1950	-	-	-	-	-	127.4	130.9	133.6	136.8	140.9	-	148.5
15-G	Yes	302	2537.9	1954	-	-	-	-	-	-	-	-	-	157.9	161.5	166.3
15-N	No	251	2525.5	1950	-	-	-	-	-	134.2	136.3	138.9	143.0	148.0	151.2	151.1
16-A	Yes	308	2515.4	1931	118.5	121.3	127.2	128.4	130.5	-	136.6	138.0	142.3	147.0	152.5	153.8
16-C	Yes	393	2495.1	1947	-	-	114.8	116.6	-	126.4	127.2	131.1	132.7	136.6	141.8	142.5
16-L	Yes	370	2478.4	1948	-	-	-	104.9	108.9	111.8	112.7	116.3	117.4	119.5	122.6	124.8
17-A	Yes	280	2475.1	1946	105.8	-	107.4	110.5	114.4	118.2	120.9	123.2	124.7	129.0	130.5	132.2
17-G	Yes	300	2456.2	1947	-	-	90.8	92.9	96.5	-	-	111.8	111.7	115.8	114.1	116.2
17-J	Yes	300	2469.1	1953	-	-	-	-	-	-	-	-	-	115.4	119.3	120.4
17-K	No	-	2454.4	1907	75.7/	-	-	-	-	-	-	-	-	-	-	-
17-K	Yes	290	2455.9	1949	-	-	-	-	99.9	-	-	-	-	-	112.3	-
17-P	Yes	315	2479.2	1955	-	-	-	-	-	-	-	-	-	-	121.7	124.1
18-E	Yes	400	2414.9	1955	-	-	-	-	-	-	-	-	-	-	109.3	106.1
18-H	Yes	350	2429.7	1948	-	-	-	84.0	89.3	95.0	98.1	-	102.0	107.2	107.1	107.2
19-F	Yes	315	2453.1	1950	-	-	-	-	-	100.8	98.2	99.8	105.5	105.7	108.2	111.0
20-G	Yes	370	2482.0	1954	-	-	-	-	-	-	-	-	-	122.5	125.0	124.6
20-J	Yes	320	2490.4	1950	-	-	-	-	-	108.0	111.7	114.9	120.3	125.7	128.9	129.3
20-L	No	-	2477.3	1908	90.4/	-	-	-	-	-	-	-	-	-	-	-
20-L	Yes	300	2477.2	1950	-	-	-	-	-	105.6	-	113.0	116.6	120.6	123.9	125.1
21-B	No	-	2507.0	1907	103.1/	-	-	-	-	-	-	-	-	-	-	-
21-D	Yes	292	2482.6	1949	-	-	-	-	104.6	-	109.6	112.4	-	121.6	123.1	-
21-E	No	250	2500.2	1954	-	-	-	-	-	-	-	-	-	136.3	134.7	133.9
21-J	No	-	2524.9	1907	117.1/	-	-	-	-	-	-	-	-	-	-	-
21-K	No	-	2514.0	1955	-	-	-	-	-	-	-	-	-	-	142.7	142.1
21-P	No	400	2536.2	1953	-	-	-	-	-	-	-	-	150.3	151.5	159.4	158.5
22-B	Yes	130	2539.8	1946	134.4	-	135.1	136.5	138.3	140.8	143.4	146.1	150.0	154.7	158.4	161.9
22-J	No	-	2539.1	1955	-	-	-	-	-	-	-	-	-	-	156.9	159.9
22-K	Yes	314	2542.4	1955	-	-	-	-	-	-	-	-	-	-	157.7	160.6
23-A	Yes	536	2587.1	1951	-	-	-	-	-	-	175.9	178.0	180.9	186.1	190.6	195.9
24-C	Yes	475	2599.3	1953	-	-	-	-	-	-	-	-	-	195.0	194.8	205.1

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface — First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
							Township 14 South, Range 14 East (continued)									
24-F	No	-	2602.1	1947	-	-	179.6	180.6	182.0	-	185.7	187.6	189.4	-	197.0	205.5
24-K	Yes	550	2618.5	1954	-	-	-	-	-	-	-	-	-	202.8	207.7	215.0
24-N	Yes	850	2632.3	1953	-	-	-	-	-	-	-	-	212.0	210.1	214.1	220.0
24-P	Yes	541	2651.2	1955	-	-	-	-	-	-	-	-	-	-	223.2	230.3
25-E	Yes	400	2640.4	1944	203.2*	-	203.5	209.3	209.6	211.1	-	213.1	-	213.2	216.3	222.7
26-F	Yes	258	2611.6	1946	182.3*	-	182.8	183.1	183.4	185.8	186.0	189.4	192.1	194.2	196.4	200.3
28-B	Yes	207	2528.5	1954	-	-	-	-	-	-	-	-	-	141.4	145.7	147.8
28-D	No	-	2517.7	1907	107.6/	-	-	-	-	-	-	-	-	-	-	-
28-D	No	170	2517.4	1947	-	-	112.7	113.2	114.2	116.5	118.8	-	-	-	-	-
29-A	Yes	300	2513.9	1949	-	-	-	-	114.6	119.9	120.4	124.6	130.0	134.7	138.7	139.7
29-F	Yes	490	2511.0	1954	-	-	-	-	-	-	-	-	-	127.7	133.7	134.4
39-C	Yes	121	2458.0	1946	77.7*	-	77.3	78.5	78.9	82.8	84.7	87.0	87.6	88.7	89.4	90.7
30-D	Yes	458	2460.5	1951	-	-	-	-	-	-	92.3	88.6	90.5	91.2	88.2	89.1
30-I	Yes	195	2496.0	1946	99.0*	-	99.5	100.2	101.0	103.3	104.0	106.4	106.8	108.6	110.8	112.8
30-J	Yes	545	2487.9	1951	-	-	-	-	-	-	94.4	98.8	-	-	105.3	106.8
30-M	Yes	284	2482.9	1947	-	-	79.8	80.7	81.7	84.0/	-	-	-	-	-	-
30-N	Yes	350	2475.5	1955	-	-	-	-	-	-	-	-	-	-	97.1	108.2
31-B	No	185	2497.6	1946	86.8	-	87.2	88.4	89.2	-	-	-	-	-	-	-
31-D	No	-	2469.1	1907	69.6	-	-	-	-	-	-	-	-	-	-	-
32-J	No	-	2540.3	1952	109.3	-	-	-	-	-	-	-	111.3	112.8	113.5	114.5
32-P	Yes	166	2553.1	1946	114.8*	-	114.5	115.2	115.6	-	116.8	117.5	119.5	119.7	-	122.0
35-A	Yes	401	2643.4	1941	198.0	-	203.3	203.1	204.2	205.6	206.7	210.2	211.8	211.9	214.3	219.1
35-H	Yes	405	2650.3	1941	197.0	-	205.9	206.0	206.6	208.0	209.0	211.1	213.2	214.3	216.9	220.9
35-O	No	250	2652.9	1947	-	-	190.2	190.2	191.0	-	-	-	-	-	-	-
35-N	Yes	225	2644.8	1952	-	-	-	-	-	-	-	184.3/	-	-	-	-
							Township 14 South, Range 15 East									
1-B	No	-	2609.8	1947	-	-	38.7	40.4	39.2	41.7	42.2	21.6	26.0	38.4	35.6	33.1
1-F	No	125	2595.9	1946	28.2	-	-	27.4	32.4	-	-	16.0	-	-	23.4	21.3
1-H	No	-	2599.9	1946	22.3	-	23.0	27.2	21.1	30.5	29.3	12.2	19.0	23.3	29.6	26.6
1-I	No	-	2598.1	1946	21.7	-	22.5	24.5	19.5	29.8	26.2	9.0	18.0	-	25.7	24.2
1-K	No	-	2587.4	1955	-	-	-	-	-	-	-	-	-	-	22.9	21.2

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface: First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
								Township 14 South, Range 15 East (continued)								
1-M	No	-	2576.1	1953	-	-	-	-	-	-	-	-	25.8	30.2	34.0	32.7
2-C	No	-	2558.0	1946	29.8	-	30.2	31.2	32.0	33.4	33.9	32.1	33.3	34.7	-	-
2-F	No	-	2565.6	1954	-	-	-	-	-	-	-	-	-	41.1	41.6	41.9
2-G	No	-	2572.6	1954	-	-	-	-	-	-	-	-	-	49.4	47.5	46.8
2-M	No	201	2609.7	1946	83.8	-	84.9	85.8	87.0	88.2	88.8	86.3	86.8	88.4	89.1	89.3
3-F	Yes	300	2565.5	1953	-	-	-	-	-	-	-	-	61.4	-	62.6	-
3-I	No	-	2574.7	1946	52.1	-	53.3	53.9	55.0	56.3	56.5	52.5	55.3	56.7	-	-
3-K	No	-	2571.6	1947	-	-	69.3	70.3	71.2	70.6	68.7	-	-	72.1	72.5	72.5
4-B	No	-	2526.8	1946	32.9	-	32.9	34.7	-	-	-	-	-	-	-	-
4-C	No	115	2547.4	1946	55.8	-	56.0	57.7	57.5	58.7	59.7	55.8	-	-	-	-
4-M	No	-	2578.9	1947	-	-	86.1	88.0	88.8	90.7	89.8	88.4	87.8	88.9	89.0	88.9
4-M	No	240	2583.9	1947	-	-	150.8	151.5	153.3	-	155.8	157.6	159.7	161.7	163.4	165.9
5-A	No	103	2548.7	1947	-	-	64.5	65.9	65.5	66.6	68.6	65.7	66.0	67.4	67.0	67.4
5-C	No	-	2543.5	1908	83.3	-	-	-	-	-	-	-	-	-	-	-
5-H	No	-	2559.2	1946	70.1	-	70.2	72.5	-	76.2	-	70.9	71.7	72.2	72.2	73.7
5-P	No	195	2582.9	1947	-	-	150.6	152.4	-	154.3	-	-	-	-	163.3	165.3
5-P	No	105	2580.1	1946	93.4	-	94.3	95.0	95.9/	-	-	-	-	-	-	-
6-D	No	134	2491.9	1946	72.6	-	73.4	74.5	76.7	78.1	-	82.2	87.3	86.1	89.1	91.3
6-E	No	-	2493.7	1909	67.6	-	-	76.8	-	-	-	-	-	-	-	-
6-H	Yes	200	2521.1	1949	-	-	-	-	95.3	95.4	97.1	99.0	102.0	104.2	106.1	106.7
6-J	No	-	2526.2	1955	-	-	-	-	-	-	-	-	-	-	116.7	119.1
6-P	No	-	2534.8	1955	-	-	-	-	-	-	-	-	-	-	124.2	126.3
7-C	No	355	2561.3	1952	-	-	-	-	-	-	-	149.6	152.3	154.5	156.9	159.5
7-F	No	-	2575.0	1955	-	-	-	-	-	-	-	-	-	-	169.3	172.4
7-O	No	189	2606.2	1940	-	178.7	182.2	183.1	184.4	186.1	188.1	-	-	-	-	-
8-H	Yes	175	2560.3	1946	127.5	-	127.1	129.1	-	131.3	-	133.9	136.5	138.7	140.2	141.9
8-O	Yes	270	2583.2	1935	151.0	-	151.5	-	153.6	155.3	156.3	159.0	160.2	162.4	164.0	166.0
9-C	No	220	2588.6	1947	-	-	91.7	92.6	93.3	93.9	94.6	94.7	94.0	95.3	95.7	95.7
9-E	Yes	290	2605.2	1949	-	-	-	-	173.8	174.3	175.3	178.2	181.3/	-	-	-
9-G	No	-	2633.2	1947	-	-	134.5	135.2	136.2	-	-	-	137.7	138.4	138.7	140.7

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface: First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
								Township 14 South, Range 15 East (continued)								
9-N	Yes	255	2628.6	1947	-	-	187.6	188.5	189.5	190.9	192.3	194.1	198.7	197.7	199.4	-
10-C	No	-	2609.4	1946	103.8	-	104.5	-	106.5	107.6	-	107.5	106.5	108.5	109.0	108.9
11-I	No	300	2700.8	1947	-	-	167.1	167.8	169.0	170.0	170.9	171.1	169.7	171.0	171.9	172.3
11-P	No	276	2736.6	1947	-	-	202.6	-	204.7	204.8	-	206.4	205.5	205.8	206.2	207.3
12-D	No	51	2593.3	1947	-	-	48.8	48.6	49.2	50.8	52.5	39.0	41.7	47.7	50.3	50.6
12-E	No	-	2641.2	1946	106.2	-	107.7	108.8	110.3	110.9	111.9	112.4	109.7	111.1	112.7	113.3
12-I	Yes	313	2756.8	1950	-	-	-	-	-	216.4	-	215.7	210.2	213.8	215.7	215.1
13-I	Yes	465	2890.4	1954	-	-	-	-	-	-	-	-	-	358.3	355.1	354.8
13-M	Yes	320	2850.8	1952	-	-	-	-	-	-	-	312.4	312.6	313.0	313.9	314.5
14-G	No	-	2768.3	1947	-	-	233.0	233.5	235.1	235.7	236.5	237.4	236.9	237.2	238.7	238.6
15-H	No	-	2725.9	1947	-	-	209.7	210.7	212.0	213.0	214.4	215.0	215.5	215.7	215.8	216.7
15-O	Yes	380	2743.3	1954	-	-	-	-	-	-	-	-	-	239.9	240.9	241.4
16-C	No	-	2637.0	1946	197.0	-	197.5	198.4	199.5	200.9	202.0	203.6	205.9	207.6	209.3	210.3
16-H	No	304	2659.2	1948	-	-	-	169.5	-	171.3	-	171.7	173.0	173.8	174.3	-
17-H	No	-	2599.9	1946	160.9	-	161.3	-	163.3	164.9	165.6	167.5	169.8	171.6	173.6	174.2
18-C	No	-	2595.3	1955	-	-	-	-	-	-	-	-	-	-	192.5	192.5
18-N	Yes	340	2620.1	1952	-	-	-	-	-	-	-	199.1	-	-	213.6	213.5
20-A	Yes	304	2623.5	1948	-	-	-	172.8	172.5	175.7	175.8	-	-	-	181.6	181.0
20-B	Yes	400	2667.8	1948	-	-	-	226.0	226.0	228.3	229.0	229.2	231.8	233.8	235.3	236.3
21-A	Yes	320	2697.1	1948	-	-	-	194.6	195.5	196.8	197.8	197.9	198.4	200.8	200.2	200.3
21-L	No	-	2649.7	1954	-	-	-	-	-	-	-	-	-	183.2	187.1	181.7
21-N	No	-	2650.8	1938	164.3	-	168.3	169.8	170.4	171.5	173.7	172.7/	-	-	-	-
21-N	Yes	385	2656.3	1942	170.0	-	172.8	-	-	175.2	176.8	176.1	-	184.7	187.1	179.9
22-H	No	-	2783.4	1949	-	-	-	-	249.3	250.3	251.3	251.9	252.8	252.9	254.1	-
22-O	No	-	2738.1	1952	-	-	-	-	-	-	-	224.1	226.5/	-	-	-
23-C	No	330	2814.2	1947	-	-	275.0	-	275.8	276.8	278.5	278.6	279.0	279.6	280.3	-
23-D	No	-	2790.2	1948	-	-	-	255.1	255.9	256.7	-	258.3/	-	-	-	-
23-L	No	343	2805.0	1950	-	-	-	-	-	268.5	269.5	270.2	270.9	271.6	272.9	272.7
23-M	No	-	2789.7	1949	-	-	-	-	252.0	253.6	-	255.1	256.1	256.7/	-	-
24-A	Yes	449	2928.8	1953	-	-	-	-	-	-	-	-	386.7	387.0	387.9	387.1

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface: First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
									Township 14 South, Range 15 East (continued)							
24-D	No	-	2881.7	1947	-	-	334.7	335.7	336.6	335.8	-	339.3	-	341.8	341.2	342.0
24-L	Yes	420	2889.4	1952	-	-	-	-	-	-	-	344.3	350.2	351.3	346.1	346.7
25-B	Yes	493	2931.5	1953	-	-	-	-	-	-	-	-	380.3	381.1	382.0	382.7
25-C	No	415	2927.7	1947	-	-	372.0	373.3	373.9	375.2	376.6	377.0	378.0/	-	-	380.0
25-C	Yes	444	2906.2	1946	358.5	-	348.9	349.5	-	351.0	-	353.6	354.8	357.8	359.1	362.6
25-E	No	423	2888.5	1951	-	-	-	-	-	-	334.9	335.8	336.5	337.5	338.4	338.7
25-H	Yes	350	2971.8	1947	-	-	247.0	-	250.3	-	-	264.2/	-	-	-	-
25-M	No	-	2864.5	1955	-	-	-	-	-	-	-	-	-	-	310.1	309.0
26-B	Yes	422	2859.9	1947	-	-	307.3	308.1	308.9	310.0	311.1	311.9	312.6	313.3	314.3	314.6
26-M	Yes	300	2753.2	1954	-	-	-	-	-	-	-	-	-	206.6	207.4	205.9
28-K	No	-	2702.9	1949	-	-	-	-	200.0	195.2	199.7	198.1	208.4	207.4	200.0	206.3
29-D	Yes	565	2683.5	1954	-	-	-	-	-	-	-	-	-	230.2	233.1	240.4
29-L	Yes	550	2701.3	1955	-	-	-	-	-	-	-	-	-	-	244.2	249.8
32-D	Yes	550	2718.8	1954	-	-	-	-	-	-	-	-	-	253.0	255.7	259.5
32-L	No	-	2754.2	1947	-	-	269.6	270.6	270.0	270.6	271.2	272.0	272.9	274.8	277.1	279.2
34-A	No	-	2725.2	1938	170.4	-	172.3	174.9	175.7	176.4	175.9	176.7/	-	-	-	-
34-F	Yes	385	2734.3	1953	-	-	-	-	-	-	-	-	192.0	198.7	-	195.9
35-A	No	-	2849.3	1951	-	-	-	-	-	-	279.9	281.0	282.5	284.5	285.3	283.6
35-F	No	-	2742.4	1953	-	-	-	-	-	-	-	-	182.9	186.8	-	182.8
35-J	No	-	2760.9	1955	-	-	-	-	-	-	-	-	-	-	200.7	196.6
35-P	No	250	2801.6	1950	-	-	-	-	-	212.9	214.6	214.2	215.8	-	217.9	210.3
36-C	Yes	451	2916.7	1954	-	-	-	-	-	-	-	-	-	350.9	352.2	351.2
36-D	Yes	406	2882.5	1947	-	-	311.0	-	-	-	-	-	-	308.3	320.2	319.4
36-H	Yes	323	2947.5	1948	-	-	-	225.0	-	227.6	229.7	228.6	229.3	229.2	230.3	230.3
									Township 14 South, Range 16 East							
3-I	No	-	2714.3	1947	-	-	16.1	15.6	15.1	16.1	17.1	14.9	15.3	15.8	16.7	17.3
3-M	No	-	2675.0	1946	12.4	-	20.7	-	5.7	28.1	-	5.7	11.1	8.4	26.2	28.4
4-H	No	-	2701.0	1949	-	-	-	-	37.8	38.4	43.9	23.1	37.6	37.8	38.1	37.2
4-L	No	-	2657.4	1952	-	-	-	-	-	-	-	12.9	13.9	16.8	19.3	18.4
4-M	No	-	2660.2	1955	-	-	-	-	-	-	-	-	-	-	20.6	19.8

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface — First record Year	Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
								Township 14 South, Range 16 East (continued)								
4-N	No	-	2666.2	1946	15.5	-	20.2	-	11.7	-	-	10.5	12.5	16.7	-	-
4-P	No	-	2672.2	1947	-	-	21.0	-	5.7	29.7	34.5	5.9	10.4	11.8	27.5	27.8
5-I	No	-	2647.6	1947	-	-	10.3	16.3	9.9	17.8	-	8.2	9.9	7.5	14.5	13.0
5-J	No	-	2638.6	1947	-	-	8.9	13.3	6.8	12.7	-	7.8	8.4	-	11.1	-
5-K	No	-	2631.7	1948	-	-	-	14.1	5.5	10.3	10.5	5.0	5.8	-	-	11.0
5-L	No	-	2638.5	1955	-	-	-	-	-	-	-	-	-	-	16.7	11.8
5-L	No	-	2638.2	1955	-	-	-	-	-	-	-	-	-	-	14.5	12.8
5-P	No	-	2653.9	1946	17.6	-	18.4	-	16.5	27.3	23.8	15.7	16.2	19.9	21.1	20.0
6-C	No	-	2614.3	1953	-	-	-	-	-	-	-	-	25.1	25.0	26.3	23.8
6-D	No	28	2604.1	1955	-	-	-	-	-	-	-	-	-	-	27.0	27.1
6-E	No	64	2604.0	1953	-	-	-	-	-	-	-	-	25.0	26.0	25.5	25.0
6-I	No	-	2640.0	1947	-	-	39.4	-	-	-	-	26.0	34.8	39.8	40.7	39.2
6-I	No	-	2626.0	1952	-	-	-	-	-	-	-	7.9	12.8	15.0	20.1	19.9
6-K	No	-	2606.8	1953	-	-	-	-	-	-	-	-	17.3	20.5	25.5	23.4
6-L	No	-	2599.5	1953	-	-	-	-	-	-	-	-	12.7	-	20.8	18.6
6-L	No	24	2600.7	1940	-	20.6-	21.0	25.3	15.8	-	26.0	9.5/	-	-	-	-
6-M	No	-	2636.8	1954	-	-	-	-	-	-	-	-	-	63.0	62.6	62.9
7-B	No	-	2690.6	1950	-	-	-	-	-	115.9	117.4	116.8	116.1	116.9	117.4	117.8
7-B	No	-	2687.9	1950	-	-	-	-	-	52.6	52.8	52.6	52.5/	-	-	-
7-M	No	-	2802.5	1950	-	-	-	-	-	-	228.1	227.5	227.7/	-	-	-
18-B	Yes	341	2829.0	1955	-	-	-	-	-	-	-	-	-	-	255.5	256.0
19-F	No	-	2969.0	1946	220.7	-	-	220.1	224.5	-	-	216.9	292.9	260.0	233.7	-
31-D	Yes	312	2974.7	1946	255.6	-	255.0	255.6	256.0	256.6	257.1	258.0	258.5	259.0	259.8	260.0
								Township 15 South, Range 13 East								
1-E	No	70	2475.4	1947	-	-	62.2	62.8	63.9	65.0	65.8	67.2	68.1	70.4	69.3	66.8
1-F	No	-	2488.0	1946	54.4	-	53.6	54.2	54.9	58.0	59.2	58.9	60.0	61.3	61.5	61.0
1-K	Yes	59	2489.6	1939	52.2	53.4	53.6	54.3	55.4	60.2	-	59.1	-	59.5	62.3	61.9
2-B	No	-	2464.3	1955	-	-	-	-	-	-	-	-	-	-	83.1	77.1
2-D	No	-	2430.6	1931	32.0	34.4	51.0	-	-	54.0	-	56.6	58.8	60.7	58.0	50.3

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface: First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
									Township 15 South, Range 13 East (continued)							
2-F	No	-	2465.4	1955	-	-	-	-	-	-	-	-	-	-	80.4	74.7
2-G	No	-	2452.0	1907	28.5/	-	-	-	-	-	-	-	-	-	-	-
2-K	No	-	2434.0	1931	31.6	-	40.2	-	-	-	-	51.9	-	55.6	-	-
2-M	No	-	2443.6	1931	30.4	31.3	36.7	42.5	44.0	50.5	55.5	55.6	58.5	60.2	59.4	52.7
3-H	Yes	142	2439.0	1946	40.2	-	-	48.1	50.3	-	55.3	58.4	-	61.6	60.0	53.1
3-O	No	230	2448.0	1913	25.4	-	37.7	-	41.8	45.3	44.5	51.3	51.1	54.9	51.0	49.2
4-K	Yes	388	2487.8	1948	-	-	-	103.5	90.7	87.6	86.8	-	-	-	-	-
8-P	No	-	2516.8	1947	-	-	67.2	61.6	66.3	65.0	62.8	-	62.7	61.2	61.4	-
10-B	No	-	2455.7	1955	-	-	-	-	-	-	-	-	-	-	57.3	-
10-J	Yes	141	2462.8	1946	39.3	-	-	-	42.8	46.8	43.4	49.6	-	60.2	57.8	-
10-N	No	-	2462.0	1955	-	-	-	-	-	-	-	-	-	-	59.0	-
10-O	No	-	2470.1	1950	-	-	-	-	-	47.3	45.2	52.5	-	65.7	55.7	52.2
11-A	Yes	150	2481.0	1953	-	-	-	-	-	-	-	-	54.8	56.4	55.4	54.5
11-D	No	-	2448.9	1934	29.7	31.2	34.6	35.9	35.9	37.0	38.6	37.6	-	-	-	-
11-E	No	-	2447.7	1948	-	-	-	28.1	28.6	30.0	29.7	33.2	44.2	51.6	31.4	30.1
11-L	No	-	2459.9	1932	31.0	36.3	44.4	46.1	48.5	50.2	51.5	53.8	58.0	62.1	58.7	51.1
11-O	No	90	2492.6	1947	-	-	51.2	51.5	51.8	52.2	52.4	52.4	53.5	53.7	53.3	52.0
11-P	Yes	150	2490.7	1952	-	-	-	-	-	-	-	54.8	56.3	56.3	55.7	54.7
12-A	No	145	2521.0	1930	62.1	62.2	63.3	64.2	64.8	65.3	66.2	67.6	69.0	70.9	70.3	-
12-G	No	-	2502.9	1946	51.8	-	53.8	53.1	54.2	55.1	56.6	57.7	59.2	60.1	61.8	58.5
13-H	No	-	2539.4	1946	63.4	-	63.5	64.6	64.7	65.5	65.7	65.8	68.3	68.7	68.4	67.6
13-H	Yes	130	2547.7	1952	-	-	-	-	-	-	-	69.9	72.4	71.7	71.4	-
13-K	No	-	2520.7	1949	-	-	-	-	61.2	61.7	62.9	62.3	63.0/	-	-	-
13-P	No	-	2549.2	1946	60.2	-	60.2	60.9	61.2	61.9	65.1	67.0	67.7	68.0	69.1	68.9
14-D	Yes	265	2470.2	1947	-	-	46.5	48.3	53.7	51.0	53.4	55.1	63.2	66.7	60.4	40.4
14-F	No	-	2448.4	1947	-	-	3.3	2.7	4.3	3.8	4.7	5.0	6.7	9.4	8.8	3.7
14-G	Yes	138	2493.6	1953	-	-	-	-	-	-	-	-	52.0	52.7	50.3	47.8
14-O	No	-	2504.7	1947	-	-	54.3	-	-	-	-	55.5	-	56.8	55.9	-
14-P	Yes	128	2520.0	1952	-	-	-	-	-	-	-	61.3	62.8	62.3	61.8	60.9
15-A	No	-	2467.3	1931	36.3	37.5	44.6	45.4	49.0	-	-	50.9	-	65.4	59.7	-

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface: First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
Township 15 South, Range 13 East (continued)																
15-D	Yes	132	2477.5	1947	-	-	44.7	-	46.7	50.4	51.8	58.2	-	-	68.3	61.3
15-F	No	-	2481.2	1955	-	-	-	-	-	-	-	-	-	-	71.1	61.3
15-G	No	-	2475.8	1953	-	-	-	-	-	-	-	-	56.3	-	54.4	40.1
15-H	Yes	240	2475.7	1946	32.0	-	41.2	34.0	-	-	47.0	39.6	-	68.7	61.8	38.9
15-J	No	300	2481.0	1953	-	-	-	-	-	-	-	-	62.4	-	68.3	58.7
15-M	Yes	122	2490.0	1949	-	-	-	-	50.3	47.5	51.8	52.4	56.6	-	62.8	55.7
15-O	Yes	200	2490.6	1948	-	-	-	46.3	-	-	-	49.5	60.3	-	65.2	49.1
15-P	No	133	2490.0	1931	46.8	48.3	-	-	-	-	-	63.2	-	-	74.3	63.6
16-N	No	50	2498.0	1947	-	-	47.0	47.6	48.7	-	-	-	-	-	-	-
17-O	No	-	2513.7	1949	-	-	-	-	61.0	61.8	63.2	64.2	65.9	68.1	71.6	68.3
20-N	No	-	2537.2	1953	-	-	-	-	-	-	-	-	73.9	74.1	77.3	-
21-A	No	-	2495.0	1950	-	-	-	-	-	45.7	46.5	48.7/	-	-	-	-
21-C	No	80	2506.1	1932	48.3	-	52.0	51.6	52.3	-	-	-	-	-	60.0	-
21-K	No	47	2506.1	1933	42.9	44.8	46.7/	-	-	-	-	-	-	-	-	-
21-K	No	80	2508.7	1948	-	-	-	48.8	49.6	50.1	50.5	51.5	52.5	53.9	55.7	55.0
21-N	No	-	2534.1	1947	-	-	68.8	69.4	69.7	70.4	71.2	71.9	-	74.2	75.3	-
22-G	Yes	56	2501.0	1932	29.5	33.4	35.1	35.6	36.4	36.7	36.5	35.5	36.8	37.2	36.3	35.5
22-J	No	-	2507.0	1949	-	-	-	-	-	36.3	36.9	36.3	-	-	-	-
22-M	No	-	2510.6	1950	-	-	-	-	-	48.4	52.5	52.9	55.8	56.7	55.5	54.4
23-A	No	-	2527.5	1950	-	-	-	-	-	51.5	51.5	52.1	52.8	53.4	53.1	51.8
23-G	No	-	2499.8	1952	-	-	-	-	-	-	-	35.6	36.2	38.1	36.2	34.0
23-J	No	46	2519.7	1947	-	-	40.9	41.6	42.6	42.4	42.7	42.9	43.4	43.8/	-	-
23-L	No	-	2504.7	1947	-	-	34.2	34.4	35.3	36.2	35.8	34.6	35.5	37.1	35.5	34.7
26-A	No	27	2527.0	1939	24.9*	25.6	23.1	22.0	25.3	25.9	24.9	25.6	26.1	28.9	26.7	25.7
26-B	No	-	2526.8	1955	-	-	-	-	-	-	-	-	-	-	25.4	41.0
26-E	No	-	2502.4	1935	9.2*	8.6	10.3	10.5	12.5	13.3	13.9	11.9	14.5	15.9	14.0	11.6
26-M	No	-	2534.9	1954	-	-	-	-	-	-	-	-	-	30.4	29.3	-
27-A	No	-	2518.4	1955	-	-	-	-	-	-	-	-	-	-	34.4	33.7
27-B	Yes	45	2518.9	1933	22.5	25.8	28.5	29.3	30.1	31.0	32.3	33.4	35.3	36.6	34.3	32.8
27-D	No	31	3524.6	1950	-	-	-	-	-	30.6	31.3	33.1	34.8	38.0	38.0	35.4

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface: First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
									Township 15 South, Range 13 East (continued)							
27-F	No	-	2526.5	1950	-	-	-	-	-	27.8	28.1	29.1	30.8	-	-	-
27-M	No	-	2539.3	1950	-	-	-	-	-	37.3	31.9	39.2	-	-	-	-
27-P	Yes	239	2534.1	1940	-	23.6	25.4	26.4	28.0	28.8	28.7	29.4	30.6	32.1	30.9	29.6
34-K	No	-	2569.7	1946	53.0	-	54.0	55.7	57.0	58.2	58.3	59.6	60.4	61.8	61.3	60.3
35-M	Yes	128	2549.2	1935	23.0	25.1	-	-	-	-	-	25.1	-	-	-	-
35-N	No	-	2550.5	1954	-	-	-	-	-	-	-	-	-	39.9	34.9	33.5
									Township 15 South, Range 14 East							
2-G	No	-	2665.6	1949	-	-	-	-	179.3	179.8	180.0	180.4	-	180.4	183.2	184.6
2-M	No	-	2670.2	1950	-	-	-	-	-	169.9	170.0	170.4	170.8	172.2/	-	-
2-P	Yes	-	2686.5	1949	-	-	-	-	182.8	183.5	183.4	184.3	-	-	186.4	186.4
4-E	No	167	2591.4	1946	107.8	-	108.9	107.8	107.8	108.2	-	-	-	-	-	-
4-K	No	185	2590.7	1946	108.1	-	108.4	108.8	109.0	109.3	110.1	110.4	113.9	111.0	111.6	111.9
4-M	No	-	2590.5	1946	107.2	-	107.5	107.8	107.6	-	-	109.4	109.8	110.3	110.8	111.1
5-B	Yes	151	2555.0	1946	96.0	-	96.0	97.7	97.1	97.4	97.8	98.2	98.9	99.3	99.8	101.5
6-K	No	-	2529.6	1953	-	-	-	-	-	-	-	-	75.7	75.8	78.0	76.3
6-N	No	-	2525.3	1946	68.6	-	68.9	68.8	69.5	69.9	70.9	70.5	71.4	72.7	74.5	72.5
6-O	No	100	2537.8	1946	73.7	-	73.3	-	71.3	74.6	75.9	-	-	78.0	78.0	77.2
7-D	No	70	2524.1	1946	65.5	-	65.6	-	66.3	68.1	68.6/	-	-	-	-	-
7-L	No	65	2534.8	1946	62.3	-	62.5	63.6	63.6	64.1	64.5	65.7	69.3/	-	-	-
7-L	Yes	280	2530.5	1954	-	-	-	-	-	-	-	-	-	67.7	-	66.2
7-O	No	-	2553.9	1954	-	-	-	-	-	-	-	-	-	74.6	79.6	74.3
9-M	No	-	2612.7	1953	-	-	-	-	-	-	-	-	111.4	111.8	112.0	112.2
10-I	Yes	223	2659.0	1948	-	-	-	145.9	146.0	146.4	146.5	146.7	-	147.9	148.1	148.0
13-A	Yes	295	2757.6	1946	219.0	-	219.2	218.6	219.4	219.5	219.7	219.9	220.0	220.5	-	-
13-H	No	-	2753.5	1949	-	-	-	-	210.1	210.5	-	210.9	211.0	211.5	212.0	212.1
15-P	No	-	2690.5	1947	-	-	161.6	161.5	-	-	-	163.4	162.5	162.9	163.2	163.3
16-D	No	-	2624.8	1946	117.9	-	118.0	118.1	118.2	118.5/	-	-	-	-	-	-
17-B	Yes	165	2600.7	1946	102.5	-	102.7	103.0	-	103.1	103.5	104.9/	-	-	-	-
17-K	No	137	2582.3	1946	80.1	-	80.1	80.3	80.5	80.8	81.2	81.5	82.1	82.4	82.5	82.6
17-M	No	-	2600.9	1954	-	-	-	-	-	-	-	-	-	100.2	100.2	100.5
17-N	No	-	2590.6	1954	-	-	-	-	-	-	-	-	-	87.8	87.7	87.9
18-B	No	-	2554.2	1946	67.0	-	66.9	67.2	67.5	67.9	68.2	68.5	69.6/	-	-	-

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface: First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
								Township 15 South, Range 14 East (continued)								
18-I	No	-	2570.4	1948	-	-	-	76.9	76.3	76.8	78.7	77.7	78.5	79.0	78.8	78.8
18-L	Yes	250	2561.4	1946	72.3	-	73.2	72.7	73.1	73.4	75.7	77.1	79.6	76.7	76.2	76.9
18-L	Yes	320	2551.0	1946	69.6	-	69.8	70.6	71.2	71.8	72.1	73.3	-	74.7	74.5	74.5
18-P	No	-	2577.1	1948	-	-	-	79.9	80.3	80.6	82.6	81.6	82.6	82.5	82.4	82.2
19-C	Yes	310	2572.9	1949	-	-	-	-	75.9	76.2	78.8	83.4	83.8	83.7	82.7	83.5
19-M	Yes	350	2564.9	1954	-	-	-	-	-	-	-	-	-	56.4	55.7	56.2
27-K	No	180	2683.6	1947	-	-	139.8	139.0	-	-	-	139.8	139.8	140.3	140.5	141.4
29-N	No	87	2619.8	1946	81.1	-	81.8	81.6	82.5	82.1	82.2	82.3/	-	-	-	-
30-H	Yes	504	2601.8	1955	-	-	-	-	-	-	-	-	-	-	82.9	81.5
30-M	No	140	2587.4	1946	57.0	-	57.7	57.8	58.4	58.7	58.8	59.8	60.5	61.5	61.3	62.6
31-E	No	-	2595.3	1946	60.7	-	58.5	59.5	60.1	60.8	61.0	62.0	62.7	63.8/	-	-
31-L	Yes	350	2597.1	1954	-	-	-	-	-	-	-	-	-	65.4	63.4	63.8
31-M	No	-	2581.9	1946	41.8	-	41.8	43.2	43.8	44.3	44.2	44.3	44.4/	-	-	-
31-N	No	100	2595.2	1946	52.7	-	53.7	53.3	54.0	54.6	54.6	55.6	56.0	57.0	56.7	56.5
33-A	No	142	2678.0	1947	-	-	133.6	132.0	132.3	132.3	133.6	133.1	133.3	133.3	134.0	134.7
34-D	No	-	2690.0	1955	-	-	-	-	-	-	-	-	-	-	143.9	145.8
								Township 15 South, Range 15 East								
6-D	Yes	492	2717.4	1952	244.6	-	-	-	-	-	-	-	246.8	252.4	255.7	257.9
6-E	No	-	2717.4	1952	-	-	-	-	-	-	-	244.6	246.8	252.4	255.7	-
6-P	No	-	2753.8	1952	-	-	-	-	-	-	-	258.7	239.3	240.6	241.5	242.6
7-J	No	290	2762.1	1952	233.0	-	-	-	-	-	-	-	233.3	233.7	234.2	234.2
8-J	Yes	314	2799.3	1947	-	-	257.5	257.4	257.7	257.9	258.3	258.5	259.1	259.5	260.3	261.0
15-K	No	440	2899.0	1952	-	-	-	-	-	-	-	326.0	326.5	326.7	327.5	328.0
18-D	Yes	417	2786.8	1952	240.0	-	-	-	-	-	-	240.0	234.6	234.9	235.9	235.3
19-D	Yes	300	2779.7	1947	-	-	228.1	228.1	228.2	228.5	228.7	228.7	228.8	229.3	229.5	-
20-E	Yes	359	2803.3	1947	-	-	242.8	243.2	243.2	243.6	244.1	244.4	244.5	-	-	-
25-N	Yes	480	3026.7	1947	-	-	398.0	398.4	399.0	399.5	400.7	401.0	401.3	403.2	403.0	403.7
27-J	Yes	404	2941.5	1946	-	-	259.6	259.8	360.2	360.0	360.7	361.2	361.6	362.7	362.4	363.2

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface — First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
									Township 15 South, Range 16 East							
5-K	No	-	2957.4	1952	-	-	-	-	-	-	-	230.0	214.6	216.2	215.7	214.6
5-M	No	205	2934.9	1950	-	-	-	-	-	186.7	187.4	188.6	189.5	192.6	195.6	190.1
6-A	No	-	2989.9	1947	-	-	243.7	244.6	245.7	247.1	247.3	248.7	249.7	253.9	250.8	249.5
6-E	No	-	2809.1	1949	-	-	-	-	72.7	73.7	73.8	75.4	75.6	76.3/	-	-
6-F	No	75	2812.9	1946	72.4	-	73.3	74.4	75.0	76.2	76.8	77.1	78.1	79.0	79.4	77.9
6-K	No	-	2822.1	1947	-	-	79.8	80.4	81.8	83.1	83.8	84.2	83.5	86.6	86.0	85.4
6-L	No	-	2809.1	1949	-	-	-	-	72.7	73.3	73.8	75.4	75.6	76.3	77.0	68.2
7-A	Yes	160	2857.2	1941	91.2	-	98.5	106.6	103.7	105.4	107.0	108.1	108.2	108.4	109.6	109.1
7-J	Yes	158	2861.1	1946	97.9	-	100.7	-	-	-	-	109.9	111.1	112.1	112.3	111.2
7-N	No	400	2886.1	1955	-	-	-	-	-	-	-	-	-	-	193.0	193.6
8-E	No	-	2869.3	1954	-	-	-	-	-	-	-	-	-	117.1	119.0	117.9
8-O	No	-	2892.2	1954	-	-	-	-	-	-	-	-	-	129.4	133.2	-
8-O	No	160	2889.8	1946	63.6	-	61.6	118.8	63.7	61.8	61.6	-	58.8	64.6/	-	-
14-M	No	-	2983.9	1950	-	-	-	-	-	65.6	66.0	35.3/	55.3	64.9	64.6	58.3
14-N	Yes	255	2992.8	1955	-	-	-	-	-	-	-	-	-	-	64.1	58.0
16-D	No	-	2917.8	1947	-	-	54.3	-	58.1	57.3	55.3	-	145.3	147.4	149.9	55.2
16-G	No	180	2926.4	1954	-	-	-	-	-	-	-	-	-	101.6	119.2	-
16-J	No	258	2931.5	1954	-	-	-	-	-	-	-	-	-	140.2	144.5	-
16-M	No	-	2942.2	1951	-	-	-	-	-	-	171.3	172.9	-	172.6	175.9	175.5
16-P	Yes	265	2951.4	1946	153.3	-	-	159.5	162.4	164.8	-	171.0	166.3	172.4	174.1	172.2
17-D	Yes	268	2884.5	1955	-	-	-	-	-	-	-	-	-	-	131.6	-
17-G	No	310	2898.2	1954	-	-	-	-	-	-	-	-	-	138.0	142.4	140.9
17-H	No	-	2911.4	1946	52.9	-	51.2	75.7	53.5	53.0	50.6	50.3	47.6	57.6	51.4	45.6
18-A	Yes	361	2887.0	1942	110.0	-	124.5	-	-	132.4	138.6	134.0	134.7	134.0	139.6	-
21-A	No	300	2990.0	1950	-	-	-	-	-	200.0	204.0	206.0	203.2	206.4	208.7	208.2
22-B	Yes	225	2970.9	1949	-	-	-	-	97.6	96.9	99.2	99.5	87.6	99.6	100.6	97.1
36-J	Yes	150	-	1946	91.0	-	79.2	100.8	-	-	-	84.2/	-	-	-	-

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface: First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
								Township 16 South, Range 13 East								
2-D	Yes	232	2554.0	1934	19.7	24.2	-	-	30.4	-	-	-	34.2	39.1	37.6	36.4
2-F	Yes	180	2569.5	1935	30.6	34.0	37.8	-	-	-	-	-	43.4	-	42.9	42.0
3-K	No	106	2610.0	1947	-	-	80.6	81.1	84.3	83.7	84.4	84.3	85.5	86.6	86.0	85.7
14-A	No	-	2612.9	1947	-	-	55.0	57.7	58.3	58.8	59.8	-/	61.6	63.3	62.0	61.2
35-A	No	-	2720.4	1947	-	-	110.3	111.1	112.9	113.0	113.5	114.6	115.9	118.9	118.8	119.6
35-G	Yes	300	2756.1	1952	-	-	-	-	-	-	-	140.4	142.6	145.1	146.2	-
35-I	No	200	2735.1	1947	-	-	114.3	114.8	116.1	116.9	-	-	120.4	122.8	124.6	126.1
36-A	No	300	2670.0	1955	-	-	-	-	-	-	-	-	-	-	77.4	75.8
36-B	No	300	2666.1	1955	-	-	-	-	-	-	-	-	-	-	73.4	71.6
36-O	No	-	2690.7	1952	-	-	-	-	-	-	-	72.4	68.8	80.4	80.8	80.6
36-P	No	275	2677.4	1947	-	-	58.6	60.3	62.4	63.7	64.7	67.6	70.0	76.5	72.2	72.3
								Township 16 South, Range 14 East								
5-K	No	160	2654.8	1951	-	-	-	-	-	-	102.9	102.8	103.6	103.3	103.5	104.8
5-O	No	254	2670.9	1947	-	-	103.3	104.2	104.6	105.5	106.0	107.5	111.5	111.0	111.0	112.8
6-A	No	120	2611.8	1947	-	-	66.6	67.1/	66.1	66.5	66.9	67.1	70.2	69.6	69.9	-
6-D	No	126	2588.1	1947	-	-	40.3	41.6	42.4	43.0	43.4	44.2	46.2	47.6	46.5	46.0
6-N	No	-	2604.4	1954	-	-	-	-	-	-	-	-	-	52.3	51.4	53.3
7-B	No	48	2595.6	1940	-	41.5	41.7/	-	-	-	-	-	-	-	-	-
7-C	Yes	550	2596.1	1955	-	-	-	-	-	-	-	-	-	-	42.7	-
7-M	Yes	230	2607.7	1953	-	-	-	-	-	-	-	-	53.7	52.3	50.8	49.5
7-O	No	120	2605.9	1951	-	-	-	-	-	-	46.4	45.3	46.3	49.0	47.9	47.3
7-O	No	-	2600.3	1947	-	-	43.8	43.0	45.8	46.2	46.3	47.3/	-	-	-	-
17-E	Yes	360	2642.3	1954	-	-	-	-	-	-	-	-	-	78.0	75.7	76.6
17-P	No	-	2683.9	1954	-	-	-	-	-	-	-	-	-	108.6	108.7	109.3
18-F	No	225	2619.3	1947	-	-	49.1	50.7	52.2	52.8	54.4	54.2	55.6	-	56.6	55.2
18-G	No	-	2622.0	1948	-	-	49.5	50.0	51.5	51.9	52.4	53.2	54.5	54.9	56.3	56.3
19-C	No	-	2625.5	1955	-	-	-	-	-	-	-	-	-	-	60.3	-
19-E	No	-	2632.9	1945	54.6	-	52.8	56.7	57.7	-	-	-	62.4	66.5	63.7	-
19-L	No	-	2637.2	1955	-	-	-	-	-	-	-	-	-	-	65.4	64.9
19-M	Yes	260	2639.8	1946	54.6	-	55.0	56.4	57.2	60.5	-	61.8	64.1	68.8	66.0	64.8
19-N	Yes	200	2640.5	1945	57.1	-	55.3	57.5	58.1	-	54.7	62.3	64.7	71.4	67.7	65.1
20-D	No	-	2635.7	1954	-	-	-	-	-	-	-	-	-	66.4	65.3	66.4

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface: First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
								Township 16 South, Range 14 East (continued)								
20-F	No	-	2683.2	1954	-	-	-	-	-	-	-	-	-	112.3	111.3	111.9
20-H	Yes	540	2701.1	1954	-	-	-	-	-	-	-	-	-	128.4	126.9	127.3
20-L	No	235	2639.6	1946	49.0	-	-	-	-	-	60.8	61.0	64.4	65.9	71.4	-
20-M	Yes	447	2648.1	1951	-	-	-	-	-	-	66.9	69.1	70.6	74.5	70.9	71.3
25-L	No	-	2805.8	1948	-	-	-	192.7	192.9	193.1	193.5	194.3	197.0	194.4	194.9	195.2
29-E	No	235	2651.2	1949	-	-	-	-	63.2	64.7	65.7	66.8	68.4	73.6	69.6	70.1
29-F	No	250	2656.0	1949	-	-	-	-	61.4	63.7	-	68.4	69.4	74.2	75.2	75.0
29-G	No	150	2661.2	1949	-	-	-	-	73.1	72.5	75.9	75.1	77.7	81.8	81.2	81.6
29-H	Yes	245	2680.2	1954	-	-	-	-	-	-	-	-	-	98.0	97.8	97.3
29-J	No	190	2682.3	1947	-	-	83.6	84.5	85.8	86.8	89.3	91.0	93.0	98.3	99.1	99.0
29-N	Yes	294	2662.7	1948	-	-	-	63.3	64.6	65.6	-	71.1	71.9	78.8	76.8	-
30-J	Yes	251	2648.5	1945	61.0	-	58.7	63.5	62.2	63.0/	-	65.7	69.7	73.9	69.1	68.6
30-M	No	-	2660.2	1946	62.8	-	62.1	63.2	63.9	-	-	68.9	71.0	75.8	73.7	72.0
30-N	Yes	225	2659.1	1947	-	-	63.6	66.0	66.7	67.6	-	68.8	70.7	75.9	-	72.0
30-O	No	-	2655.7	1944	67.1	-	60.6	-	-	-	-	67.6	69.6	73.9	73.8	73.8
31-F	Yes	332	2670.0	1930	32.6	53.8-	49.1/	-	-	-	-	-	- -	-	-	-
31-F	No	-	2672.4	1953	-	-	-	-	-	-	-	-	70.4	77.0	73.6	74.8
31-G	No	346	2664.1	1931	44.8	-	49.3	-	-	-	-	61.8	62.5	67.0	64.7	-
31-O	Yes	248	2674.3	1931	50.1	54.5	55.3	59.8	59.1	60.6	-	64.2	67.4	71.6	70.4	77.4
31-P	Yes	462	2673.1	1931	40.8	45.8	49.8	55.5	52.6	55.1	72.3/	-	-	-	-	-
32-N	Yes	253	2671.6	1948	-	-	-	50.4	66.5	67.7	69.6	72.1	74.9	78.8	80.5	81.8
32-F	Yes	230	2672.9	1948	-	-	-	68.5	70.1	71.3	73.5	75.8	-	83.0	83.9	-
								Township 16 South, Range 15 East								
4-I	Yes	505	2952.5	1953	-	-	-	-	-	-	-	-	355.6	356.3	355.8	350.8
18-B	No	311	2857.7	1946	268.8	-	266.1	266.0	266.2	266.1	266.4	-	266.8	266.9	267.2	267.3
22-E	No	-	2990.5	1947	-	-	365.4	-	366.8	-	366.5	366.8	367.1	367.7	368.0	368.4
36-K	Yes	620	3199.8	1927	562.0	-	555.4	556.0	557.9	560.1	557.0	-	557.7	561.1	556.6	559.7
								Township 16 South, Range 16 East								
10-K	Yes	500	3145.2	1946	347.5	-	-	339.9	340.1	346.2	-	-	348.0	340.6	339.5	332.8
21-F	Yes	630	3258.0	1947	-	-	-	576.2	576.7	577.0	580.4	589.1	580.5	581.7	582.5	582.1

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface — First record Year	Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
								Township 17 South, Range 13 East								
1-K	Yes	306	2733.5	1953	-	-	-	-	-	-	-	-	108.9	112.6	112.9	113.1
1-N	Yes	311	2743.0	1953	-	-	-	-	-	-	-	-	109.9	117.1	117.0	118.3
12-H	No	320	2709.2	1952	-	-	-	-	-	-	-	76.0	79.9	85.6	81.2	83.0
13-B	No	-	2724.5	1952	-	-	-	-	-	-	-	80.4	85.3	89.5	85.3	86.8
13-C	No	110	2733.0	1946	76.4	-	75.9	78.5	82.6	84.9	86.0	90.1	94.2	98.6	94.6	-
13-G	Yes	125	2725.5	1931	53.1	58.7	64.6	66.3/	-	-	-	-	-	-	-	-
13-G	No	-	2727.8	1953	-	-	-	-	-	-	-	-	88.3	92.2	86.6	89.1
13-H	Yes	312	2712.0	1952	-	-	-	-	-	-	-	64.3	-	77.9	69.3	72.4
13-P	Yes	175	2720.6	1931	41.0	50.9	-	-	-	61.2	-	64.4	68.4	72.5	70.4	73.7
21-F	Yes	452	3146.6	1947	-	-	422.7	424.8	422.9	-	422.9	423.3	423.9	-	421.3	424.6
22-C	No	320	2993.5	1947	-	-	287.1	288.7	290.5	292.4	294.0	296.0	299.8	305.3/	-	-
22-E	No	410	3046.5	1947	-	-	352.4	334.8	343.0	344.9	346.8	349.1	352.4	357.4	335.7	363.0
22-J	No	370	2932.1	1947	-	-	221.4	229.2	230.9	231.9	233.4	235.5	239.3	244.8	247.0	-
24-C	No	134	2749.7	1947	-	-	71.2	71.8	74.9	76.3	78.1	78.4	82.9	88.7	88.8	91.6
24-G	No	-	2739.2	1945	57.5	-	58.7	-	61.2	63.1/	-	-	-	-	-	-
24-G	Yes	254	2739.4	1949	-	-	-	-	62.5	62.8	-	66.0	-	78.7	72.3	74.3
24-K	No	200	2752.3	1949	-	-	-	-	66.5	68.8	74.2	73.7	79.9	88.3	-	83.0
24-M	No	-	2777.3	1949	-	-	-	-	92.5	-	-	94.8	98.7	105.7	102.8	103.7
25-B	Yes	109	2744.5	1932	35.3	44.4	49.4	53.9/	-	-	-	-		-	-	-
25-B	No	-	2746.8	1954	-	-	-	-	-	-	-	-	-	70.8	65.7	67.
25-F	Yes	230	2756.1	1949	63.9	-	-	-	-	59.6	63.7	62.8	66.3	77.2	70.6	71.6
25-F	Yes	150	2754.5	1944	55.2	-	55.6	59.2	56.6	57.8	-	62.1	65.4/	-	-	-
25-K	Yes	195	2770.8	1930	57.1	61.6	66.9	69.0	68.7/	-	-	-	-	-	-	-
25-K	Yes	320	2774.1	1952	-	-	-	-	-	-	-	70.5	81.5	89.9	86.3	87.8
26-F	Yes	230	2830.0	1947	-	-	125.1	126.7	128.0	129.5	131.7	133.1	137.7	142.7	142.9	144.4
27-E	Yes	462	3034.9	1950	-	-	-	-	-	325.3	326.4	328.9	332.8	337.4	340.8	343.1
35-G	No	-	2837.6	1954	-	-	-	-	-	-	-	-	-	140.0	138.0	143.6
35-J	Yes	345	2828.1	1952	-	-	-	-	-	-	-	115.2	120.4	130.0	126.7	-
35-O	Yes	274	2837.8	1952	-	-	-	-	-	-	-	119.2	123.6	131.9	130.5	-
35-P	Yes	76	2795.3	1947	-	-	63.1	65.2	66.8	68.3	71.6	74.9	-	89.7	87.2	89.7
36-H	No	200	2770.6	1948	-	-	-	59.6	55.1	58.7	69.6	61.2	67.1	77.0	72.5	73.2
36-L	Yes	254	2786.5	1950	-	-	-	-	-	65.5	-	71.3	76.7	88.8	82.4	85.4
36-O	Yes	175	2781.9	1948	-	-	-	56.1	56.5	58.4	-	63.2	70.7	79.9	74.4	76.2

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface: First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
								Township 17 South, Range 14 East								
5-B	Yes	150	2680.5	1949	-	-	-	-	75.5	76.6	78.6	81.0	83.8	-	89.3	90.7
5-N	Yes	360	2707.1	1952	-	-	-	-	-	-	-	100.3	103.6	106.6	102.1	105.1
5-O	Yes	250	2705.3	1953	-	-	-	-	-	-	-	-	101.8	105.3	106.9	108.4
6-D	No	-	2681.6	1945	57.0	-	55.2	56.8	59.0	60.4	-	64.9	67.7	74.2	69.7	70.0
6-F	Yes	186	2679.0	1931	43.7	47.9	48.4	47.6	54.4	56.1/	-	-	-	-	-	-
6-G	Yes	289	2679.6	1931	43.9	49.7	52.1	-	56.8/	-	-	-	-	-	-	-
6-M	Yes	234	2690.7	1931	42.9	50.3	55.0	56.9	57.9	60.6	-	65.8	68.5	77.8	72.9	74.4
6-O	Yes	307	2690.3	1931	44.3	-	58.8	-	62.6	64.6	-	66.2	67.7	73.6	70.0	74.6
6-P	Yes	200	2691.6	1931	60.8	66.0	71.2	71.9	72.7	74.8	-	79.9	81.8	84.4	85.5	86.0
7-H	Yes	312	2700.4	1951	-	-	-	-	-	-	86.7	65.3	70.4	79.2	72.2	90.6
7-M	Yes	312	2705.0	1951	-	-	-	-	-	-	60.8	62.3	65.2	77.8	67.3	70.8
7-N	No	-	2703.2	1940	-	53.8	59.1	59.6	62.9	62.3	61.9	63.9	68.9	71.1	68.5	69.4
7-P	Yes	905	2705.0	1931	25.3	27.7	-	-	-	-	-	-	-	-	-	-
7-P	Yes	733	2705.1	1947	-	-	36.5	-	41.6	48.9	-	52.3	-	72.0	63.7	-
8-F	Yes	404	2708.4	1946	94.7	-	95.1	93.9	94.9	94.5/	-	93.1	101.8	-	-	-
8-F	Yes	506	2710.3	1952	-	-	-	-	-	-	-	95.0	102.7	107.4	104.4	-
8-G	No	-	2711.6	1947	-	-	51.6	88.5	64.0	73.8	-	89.2	96.2	100.5	98.2	118.6
8-K	No	-	2717.8	1949	-	-	-	-	69.9	96.6	-	98.5	-	107.5	108.3	114.3
15-D	Yes	295	2780.7	1947	-	-	163.5	164.1	165.6	166.5	-	170.0	170.7	173.1	177.8	179.0
17-L	No	-	2732.4	1954	-	-	-	-	-	-	-	-	-	-	78.3	93.8
17-O	No	-	2753.3	1953	-	-	-	-	-	-	-	-	80.9	94.5	87.4	93.1
18-G	Yes	182	2714.6	1931	56.6	58.6	61.5	63.5	65.9	66.9	-	68.7	-	74.7	73.6	-
18-K	No	67	2715.2	1940	-	53.4	56.4	58.8	60.5	64.0	66.3/	-	-	-	-	-
18-M	No	-	2722.6	1931	43.3	-	55.8	56.7	59.3	63.0/	-	-	-	-	-	-
19-C	No	-	2730.7	1939	45.6	45.8	-	59.8	54.3	59.6/	-	-	-	-	-	-
19-L	Yes	388	2737.5	1920	60.0	-	47.8	60.9	49.0	54.4	-	-	-	80.9	64.4	-
19-N	Yes	312	2741.8	1951	-	-	-	-	-	-	68.4	54.2	59.1	70.0	62.8	70.4
28-P	No	600	2871.8	1953	-	-	-	-	-	-	-	-	158.3	165.7	162.4	165.5
29-L	No	-	2797.3	1953	-	-	-	-	-	-	-	-	109.0	122.4	113.8	117.8
30-A	No	-	2787.8	1952	-	-	-	-	-	-	-	125.0	104.3	115.3	106.7	112.7

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface First record Year	Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
								Township 17 South, Range 14 East (continued)								
30-D	Yes	251	2745.0	1952	-	-	-	-	-	-	-	57.6	62.5	73.4	65.9	72.1
30-E	Yes	174	2749.6	1931	37.1	-	47.3	-	50.2	-	-	55.6	59.4	72.3	66.2	66.7
30-F	Yes	195	2750.0	1931	37.3	41.7	46.6	-	46.2	-	-	59.5	59.1	72.8	65.4	71.8
30-G	Yes	250	2748.5	1930	32.0	39.2	44.7	-	48.3	61.4/	-	-	-	-	-	-
30-J	No	-	2775.3	1952	-	-	-	-	-	-	-	75.8	85.3	96.4	92.5	93.4
30-M	No	-	2757.3	1940	-	54.7	56.9	63.9	55.2	60.2	-	57.5	64.6	63.3	64.2	64.4
30-N	No	-	2765.4	1947	-	-	56.4	78.5	-	67.4	85.9	64.4	71.9	84.1	77.2	83.2
30-O	Yes	251	2745.0	1951	-	-	-	-	-	-	60.9	57.6	62.5	73.4	-	-
31-C	Yes	118	2776.5	1947	-	-	61.6	78.4	64.2	70.0	89.1	70.2	76.4	86.8	82.6	-
31-E	Yes	207	2776.1	1955	-	-	-	-	-	-	-	-	-	-	77.7	82.3
31-F	No	-	2773.6	1947	-	-	68.9	69.3	69.2	69.8	-	69.2	-	-	-	-
								Township 17 South, Range 15 East								
6-A	No	313	2915.9	1946	289.2	-	289.5	289.5	289.8	289.9	290.3	290.4	290.5	291.3	291.5	291.7
7-N	No	306	2916.2	1946	255.5	-	255.9	255.9	255.9	255.8	256.0	256.1	256.4	256.8	256.9	-
								Township 18 South, Range 13 East								
1-E	Yes	111	2795.8	1942	52.9	-	60.4	59.4	59.5	62.2	66.4	69.6	75.3	83.4	80.8	83.1
1-F	No	-	2794.0	1933	38.1	46.5	53.2	55.5	56.1	59.2	-	66.2	72.3	79.9	77.5	80.2
1-I	No	250	2789.8	1953	-	-	-	-	-	-	-	-	67.3	75.4	71.5	73.9
1-L	Yes	260	2801.1	1954	-	-	-	-	-	-	-	-	-	83.4	80.8	83.7
1-N	Yes	250	2800.4	1940	-	44.7	51.9	53.7	54.4	58.5	-	66.2	72.3	79.1	77.0	79.6
1-N	Yes	253	2800.2	1947	-	-	49.9	53.5	53.5	56.5	-	63.5	69.9	75.1	74.0	76.8
1-O	Yes	177	2801.9	1947	-	-	51.8	56.3	55.7	58.4	-	65.1	71.3	-	73.9	79.0
11-B	Yes	295	2823.1	1950	-	-	-	-	-	84.0	-	87.5	93.0	101.5	99.5	102.9
11-N	No	-	2860.4	1946	90.1	-	91.4	93.5	95.8	99.3	-	109.7	114.7	121.1	119.2	123.4
11-O	Yes	251	2825.9	1946	56.1	-	56.3	61.4	65.2	68.9	-	72.8	-	82.7	80.6	84.6
12-N	Yes	251	2821.7	1946	54.3	-	51.3	56.6	54.8	59.4	70.4	66.7	-	79.5	76.3	81.2
12-O	Yes	300	2822.1	1952	-	-	-	-	-	-	-	68.8	75.7	-	76.0	82.8
13-A	No	500	2839.1	1953	-	-	-	-	-	-	-	-	77.5	79.3	79.0	84.2
13-B	Yes	300	2831.0	1946	52.7	-	51.0	-	-	57.7	-	66.8	-	74.8	74.1	79.4
13-C	No	216	2828.6	1931	36.3	42.8	53.2	59.3	54.5	58.4	-	67.4	-	76.6	75.5	79.8

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
				Depth to water in feet from measuring point, at approximate ground surface												
Township 18 South, Range 13 East (continued)																
13-L	Yes	264	2838.2	1947	-	-	53.1	59.5	56.7	61.8	-	70.3	-	78.2	76.2	81.3
14-E	Yes	302	2866.9	1952	-	-	-	-	-	-	-	107.6	111.4	116.2	110.3	115.8
14-N	Yes	215	2853.8	1939	42.8	-	63.1	65.8	66.9	70.4	-	-	83.5	86.1	83.5	87.8
15-C	Yes	315	2985.1	1947	-	-	209.8	211.5	212.8	216.2	218.6	-	-	-	234.3	236.0
23-C	Yes	300	2849.3	1951	-	-	-	-	-	-	65.0	64.9	68.8	72.9	69.4	73.8
23-L	No	-	2892.1	1950	-	-	-	-	-	88.2	96.1	95.2	99.1	103.2	102.3	103.0
24-D	Yes	215	2849.7	1932	35.4	45.2	55.7	-	60.0	62.8	74.3	73.0	-	80.3	76.5	81.9
24-E	No	360	2867.4	1917	40.1	54.4	64.7	-	-	-	-	-	-	-	-	-
26-A	Yes	269	2870.3	1917	27.5	38.6	-	51.8	51.6	-	-	63.6	-	69.8	69.7	68.8
26-B	Yes	251	2867.9	1948	-	-	-	51.1	52.3	55.1	-	62.1	-	68.2	66.5	67.8
26-E	Yes	395	2871.4	1945	44.6	-	-	48.5	49.7	52.4	-	58.6	64.4	64.3	63.2	64.8
27-I	Yes	377	2910.1	1952	-	-	-	-	-	-	-	88.0	-	93.4	92.0	92.8
32-P	No	-	3056.1	1948	-	-	-	173.4	174.9	175.0	177.6	179.1	185.9	184.7	185.8	185.9
34-B	Yes	266	2911.5	1917	41.8	50.3	-	61.4	62.6	63.8	-	69.2	74.1	73.3	75.6	74.0
35-C	Yes	250	2883.6	1948	-	-	-	43.3	44.3	46.5	-	53.2	60.1	57.1	56.5	57.2
35-L	Yes	270	2894.7	1954	-	-	-	-	-	-	-	-	-	53.4	53.4	53.2
36-E	No	-	2977.7	1949	-	-	-	-	129.1	130.8	135.6	134.4	138.2	139.8	139.6	140.1
Township 18 South, Range 14 East																
7-D	Yes	275	2820.9	1946	76.7	-	71.1	74.3	73.2	76.4	-	82.9	89.6	94.0	93.5	97.3
8-F	No	400	2935.6	1953	-	-	-	-	-	-	-	-	194.1	197.7	196.9	199.8
8-H	Yes	410	2972.9	1948	-	-	-	215.3	214.8	223.5	228.0	228.5	229.4	232.8	232.8	234.1
8-I	Yes	289	2992.6	1948	-	-	-	240.8	241.1	241.7	242.2	243.0	244.3	247.3	246.3	247.6
Township 19 South, Range 12 East																
24-P	No	185	3130.1	1952	-	-	-	-	-	-	-	168.1	169.7	172.1	171.6	171.5
25-N	No	-	3128.6	1949	-	-	-	-	145.2	147.4	147.3	148.8	150.3	153.1	152.4	152.2
32-P	No	49	3223.5	1953	-	-	-	-	-	-	-	-	47.2	48.0	44.0	44.2
36-P	No	-	3092.1	1940	-	87.6	-	96.8	95.3	97.7	-	-	-	-	-	-

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface: First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
								Township 19 South, Range 13 East								
3-B	No	200	2905.9	1939	30.0	-	-	39.7	41.0	42.2	-	-	-	52.5	52.0	50.8
3-D	No	112	2928.1	1917	38.1	48.7	55.1	57.1	58.2	61.4	-	67.8	-	75.3	73.5	69.8
3-H	Yes	280	2916.6	1916	25.6	-	39.0	-	43.8	45.8	-	52.2	-	55.8	-	53.0
5-G	No	250	3081.7	1949	-	-	-	-	194.3	196.0	198.1	200.1	202.8	206.1	206.0	206.6
9-F	No	-	2955.1	1953	-	-	-	-	-	-	-	-	58.6	-	60.4	59.4
9-G	No	-	2937.6	1932	22.0	28.2	-	35.5	35.3	39.4	45.7	46.5	48.0	53.3	52.5	52.2
9-J	Yes	155	2940.6	1945	29.0	-	-	31.6	30.2	-	-	-	42.7	47.8	-	-
11-B	No	-	2981.0	1953	-	-	-	-	-	-	-	-	104.3	106.3	107.4	-
16-F	Yes	235	2937.6	1949	-	-	-	-	14.9	-	-	-	19.6	24.6	-	-
20-J	No	-	2984.4	1950	-	-	-	-	-	30.5	-	33.1	36.3	38.1	35.5	33.2
20-O	No	-	2997.7	1950	-	-	-	-	-	37.3	39.5	39.6	-	43.6	-	39.5
21-C	Yes	189	2967.2	1952	-	-	-	-	-	-	-	33.4	37.1	40.0	36.4	36.0
22-B	No	-	3042.9	1950	-	-	-	-	-	119.5	120.2	121.2	122.3	-	-	125.7
28-D	No	-	2995.8	1950	-	-	-	-	-	41.8	44.1	44.0	44.9	46.7	43.8	42.4
29-J	No	-	3001.4	1953	-	-	-	-	-	-	-	-	33.1	36.3	32.6	31.5
29-L	No	-	3009.5	1940	-	28.6	-	36.3	36.8	34.3	38.5	40.0	42.8	44.8	40.3	39.1
29-M	No	-	3014.5	1945	31.1	-	-	-	34.5	36.7	36.6	37.8	39.6	41.4	38.1	37.1
30-O	No	-	3029.9	1952	-	-	-	-	-	-	-	55.6	57.3	-	-	56.7
31-E	No	314	3084.0	1952	-	-	-	-	-	-	-	101.0	102.6	104.8	104.6	103.3
31-G	No	125	3051.0	1944	62.6	-	-	-	-	-	-	-	68.4	-	-	63.4
31-O	No	175	3050.2	1941	41.2	-	-	-	49.8	48.5	-	49.1	48.7	52.5	51.9	48.5
31-P	No	-	3041.6	1950	-	-	-	-	-	39.4	39.7	39.9	40.5	42.7	41.4	39.1
32-B	No	-	3013.8	1940	-	23.8	-	-	31.5	32.8	32.4	33.7	34.6	-	32.5	32.4
32-G	No	100	3019.8	1940	-	20.7	-	30.6	31.2	-	32.3	33.4	34.0	35.7	32.9	31.7
								Township 20 South, Range 12 East								
1-F	No	350	3104.6	1952	-	-	-	-	-	-	-	108.4	108.6	111.4	110.4	110.3
1-P	No	-	3084.4	1955	-	-	-	-	-	-	-	-	-	-	64.2	63.2
2-L	No	-	3131.6	1950	-	-	-	-	-	139.1	-	139.8	141.5	146.0	-	144.2
2-O	No	-	3124.3	1953	-	-	-	-	-	-	-	-	131.4	-	134.2	133.7
2-P	No	-	3115.8	1952	-	-	-	-	-	-	-	121.1	129.9	128.9	124.8	124.3

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface — First record Year	Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
							Township 20 South, Range 12 East (continued)									
3-D	No	350	3179.2	1952	-	-	-	-	-	-	-	181.3	173.4	182.0	168.7	170.4
3-J	Yes	247	3151.1	1946	154.5	-	-	-	-	-	159.1	158.7	-	163.5	162.0	164.7
10-0	No	-	3280.9	1953	-	-	-	-	-	-	-	-	279.5	281.5	282.2	-
12-A	No	-	3074.3	1943	42.2	-	45.8	46.7	47.3	46.2	48.0	47.3	49.0	50.7	50.1	49.5
13-B	No	-	3133.0	1955	-	-	-	-	-	-	-	-	-	-	93.7	93.3
13-J	No	48	3117.2	1953	-	-	-	-	-	-	-	-	69.4	71.1	70.8	68.6
13-P	No	-	3101.9	1949	-	-	-	-	43.8	43.0	43.0	43.3	44.8	-	45.3	45.5
34-L	No	-	3194.3	1953	-	-	-	-	-	-	-	-	128.3	-	-	-
28-H	Yes	477	3498.1	1953	-	-	-	-	-	-	-	-	345.0	-	-	-
							Township 20 South, Range 13 East									
5-E	No	-	3050.5	1952	-	-	-	-	-	-	-	42.7	43.9	-	-	42.2
6-B	No	-	3042.6	1951	-	-	-	-	-	-	37.4	37.3	38.1	40.4	37.9	36.6
6-0	Yes	125	3053.3	1945	41.9	-	-	44.3	43.7	46.1	-	46.5	47.5	49.0	47.2	45.5
6-L	No	-	3071.4	1940	-	48.7	-	55.3	-	56.5	57.8	57.6	60.0	61.2	59.7	58.1
6-0	Yes	122	3049.9	1940	-	19.3	-	29.0	28.8	30.6	30.7	30.8	31.8	33.6	-	30.7
6-P	Yes	125	3054.3	1950	-	-	-	-	-	35.2	-	35.7	36.9	-	37.7	35.7
7-C	No	-	3059.9	1940	-	23.9	-	31.0	32.4	33.5	34.2	33.2	38.0	37.0	-	35.7
7-G	No	-	3063.7	1948	-	-	-	31.4	32.5	32.9	33.9	-	35.0	36.5	36.1	34.7
7-I	No	-	3145.5	1949	-	-	-	-	107.1	108.6	109.2	-	111.3	113.0	112.1	-
7-J	Yes	46	3067.0	1948	-	-	-	29.0	29.3	30.2	30.8	31.8	32.7	34.0	33.0	-
7-L	No	-	3070.6	1952	-	-	-	-	-	-	-	35.7	-	38.7	38.2	36.9
7-M	No	—	3084.4	1943	40.8	-	-	-	46.2	46.3	46.7	47.3	50.3	50.2	49.0	47.8
7-N	Yes	180	3072.6	1940	-	21.4	-	-	29.1	29.4	29.8	30.6	31.8	34.1	32.1	31.6
18-E	Yes	150	3096.4	1952	-	-	-	-	-	-	-	43.4	45.0	46.7	45.1	44.5
18-K	No	-	3092.1	1952	-	-	-	-	-	-	-	32.7	34.1	35.6	-	-
18-N	No	-	3092.1	1952	-	-	-	-	-	-	-	32.6	34.1	35.6	34.2	-
19-D	No	-	3097.2	1952	-	-	-	-	-	-	-	33.0	34.3	-	35.1	-
19-K	Yes	111	3107.7	1949	-	-	-	-	28.6	28.8	-	31.2	32.6	34.0	33.3	31.9
19-M	No	140	3124.4	1940	-	39.4	-	-	46.8	-	-	49.4	50.6	54.0	51.3	50.1
20-L	No	-	3178.9	1953	-	-	-	-	-	-	-	-	106.1	107.5	108.9	106.2

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface: First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
							Township 20 South, Range 13 East (continued)									
28-M	No	-	3331.1	1953	-	-	-	-	-	-	-	-	228.2	228.9	229.4	229.6
30-D	Yes	115	3120.6	1951	-	-	-	-	-	-	40.7	39.5	42.4	-	43.0	42.0
30-F	No	130	3124.9	1952	-	-	-	-	-	-	-	38.9	40.0	43.2	40.8	39.8
30-F	No	-	3125.0	1952	-	-	-	-	-	-	-	36.9	38.2	42.1	39.0	37.8
30-N	No	100	3146.2	1953	-	-	-	-	-	-	-	-	52.8	54.0	53.2	51.8
31-A	No	-	3137.9	1948	-	-	-	27.9	-	29.5	30.4	31.3	32.5	34.8	-	-
31-G	No	-	3145.1	1948	-	-	-	31.0	35.5	35.3	36.3	37.5	38.5	40.1	40.6	39.3
31-L	No	95.5	3186.0	1940	-	70.4	-	-	76.1	77.4	78.4	79.8	80.8	82.0	81.2	80.2
32-E	No	82	3147.4	1940	-	26.0	28.9	28.9	-	32.4	33.7	34.3	35.6	38.3	35.2	33.8
32-L	No	-	3147.8	1952	-	-	-	-	-	-	-	28.9	30.0	31.5	29.5	-
33-F	No	-	3288.5	1954	-	-	-	-	-	-	-	-	-	177.7	-	179.7
							Township 21 South, Range 12 East									
1-H	No	133	3247.5	1953	-	-	-	-	-	-	-	-	125.3	126.3	128.3	128.3
12-I	No	145	3296.9	1953	-	-	-	-	-	-	-	-	139.0	139.2	139.7	135.7
13-H	No	-	3317.8	1953	-	-	-	-	-	-	-	-	139.9	141.3	141.0	138.9
							Township 21, South, Range 13 East									
5-I	No	-	3230.9	1953	-	-	-	-	-	-	-	-	80.5	80.9	82.7	82.9
5-M	No	35	3174.2	1948	-	-	-	18.8	25.8	26.3	26.3	28.9	27.9	31.2	29.1	27.1
6-E	No	-	3228.2	1940	97.6	-	-	102.5	103.6	104.5	105.4	106.4	109.6	109.9	108.8	107.3
6-P	No	-	3181.4	1943	30.4	-	-	-	-	-	36.2	37.0	-	-	-	35.9
7-C	No	-	3233.8	1947	-	-	-	82.4	83.7	85.0	86.2	87.5	89.7	89.8	88.8	87.1
7-P	No	-	3195.1	1948	-	-	-	19.3	20.4	21.5	22.4	23.4	25.0	26.4	28.7	21.5
8-N	No	-	3200.3	1950	-	-	-	-	-	28.5	29.7	29.8	-	26.8	30.2	27.9
9-E	No	-	3248.7	1953	-	-	-	-	-	-	-	-	78.4	78.9	79.3	79.7
17-F	No	-	3206.0	1954	-	-	-	-	-	-	-	-	-	26.7	21.1	-
17-G	No	-	3208.1	1953	-	-	-	-	-	-	-	-	28.9	25.4	22.4	20.3
17-N	No	-	3216.3	1949	-	-	-	-	20.2	22.4	-	25.0	25.5	27.2	24.0	21.3
18-P	No	-	3218.9	1940	-	12.2	-	20.4	21.5	23.4	25.1	25.2	26.6	28.3	25.0	22.0
19-A	No	-	3222.4	1940	-	12.2	-	22.4	-	24.4	-	26.0	27.5	29.6	26.1	24.3
19-B	No	-	3224.3	1940	-	16.4	-	27.6	28.2	30.2	31.5	32.2	34.0/	-	-	-
19-C	No	-	3231.6	1954	-	-	-	-	-	-	-	-	-	43.3	39.4	-

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface: First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
Township 21 South, Range 13 East (continued)																
19-G	No	-	3237.5	1939	22.7	22.7	-	31.5	31.9	34.5	36.1	35.9	38.3	39.3	36.0	33.2
19-J	No	-	3243.3	1940	-	24.7	-	33.9	-	-	-	-	-	-	-	-
19-N	No	-	3239.0	1941	-	18.6	-	35.4	35.4	37.9	39.8/	—	-	-	-	-
19-I	No	-	3235.2	1940	-	18.6	26.5	26.9	27.3	29.4	-	31.3	-	29.5	32.1	-
20-M	No	-	3240.3	1940	-	19.7	-	26.0	-	28.2	29.3	29.5	32.8	32.5	30.4	26.3
29-C	No	-	3263.2	1940	-	35.4	-	-	44.8	46.2	47.2	47.7	50.5	-	48.1	-
30-C	No	-	3264.6	1940	-	42.0	-	49.5	49.2	51.5	51.8	51.8	53.7	54.4	51.3	50.1
30-J	No	-	3263.1	1941	29.8	-	-	35.4	35.0	36.5	37.3	37.2	39.9	39.8	38.3	35.4
30-O	Yes	60	3259.7	1937	25.0	-	-	-	16.0	-	19.0	22.0	20.2	22.7	20.7	17.6
31-G	No	-	3273.8	1948	-	-	-	-	27.0	27.9	29.2	29.5	31.0	32.2	30.5	27.2
31-H	No	-	3273.2	1949	-	-	-	-	26.3	28.3	29.5	29.7	30.8	32.8	28.1	24.7
31-I	Yes	72	3273.9	1940	-	11.9	-	-	20.1	22.6	23.3	17.8	25.4	26.4	-	20.3
32-L	Yes	69	3283.6	1940	-	22.6	-	-	-	-	-	-	38.7	40.4	37.1	32.4
32-M	Yes	71	3293.4	1941	23.1	-	-	-	34.4	-	-	37.4	38.8	42.0	37.1	-
32-M	Yes	70	3303.0	1949	-	-	-	-	44.3	46.1	47.9	48.4	50.1	50.4	37.5	-
32-N	No	150	3303.4	1950	-	-	-	-	-	-	-	-	-	-	-	41.8
Township 22 South, Range 13 East																
5-H	No	-	3309.0	1953	-	-	-	-	-	-	-	-	35.0	37.0	33.0	-
5-I	No	-	3312.9	1953	-	-	-	-	-	-	-	-	41.2	43.2	39.1	31.3
5-L	No	-	3298.6	1941	17.2	-	-	28.1	28.9	30.7	30.5	31.6	32.8	34.9/	-	-
5-P	No	67	3310.7	1940	-	17.8	-	31.8	32.8	35.4	-	34.9	-	38.2	-	26.5
8-B	No	-	3309.0	1939	22.1	19.5	30.8	33.2	32.5	35.2	35.2	35.3	37.6	39.7	35.2	28.7
9-F	No	-	3322.1	1941	19.0	-	-	35.3	-	36.0	-	35.4	-	39.7	-	24.2
9-I	No	73	3329.1	1944	28.1	-	-	35.3	36.4	36.8	-	35.3	-	40.2	32.8	22.3
9-J	Yes	104	3330.4	1941	21.4	-	39.0	-	39.3	39.0	39.9	40.4	42.2	44.8	40.0	29.3
15-O	No	-	3364.0	1948	-	-	-	29.7	31.4	30.7	35.3	30.0	32.7	35.7	22.7	10.1
16-H	Yes	-	3341.4	1951	-	-	-	-	-	-	32.5	33.9	36.8	39.9	29.6	18.7
26-E	No	-	3387.7	1941	10.9	-	-	-	27.7	27.3	27.7	28.3	30.3	33.2	18.0	-
26-M	Yes	70	3396.0	1936	2.4	4.9	-	30.6	27.9	27.2	-	28.6	-	33.7	-	-
27-A	No	81	3381.7	1940	-	11.3	-	36.9	31.4	31.3	-	31.3	-	37.3	20.3	9.0
27-A	No	-	3384.2	1949	-	-	-	-	32.3	23.9	-	32.9	-	37.7	21.9	9.6
34-H	No	-	3411.0	1952	-	-	-	-	-	-	-	31.1	38.8	43.6	30.0	11.8

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface — First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
Township 22 South, Range 13 East (continued)																
35-O	No	90	3430.9	1936	13.9	18.6	36.4	44.2	42.7	42.6	39.3	44.3	-	53.8	30.5	11.4
35-I	No	77	3454.0	1940	-	43.7	-	72.7	69.0	-	64.7	70.0	71.9	79.9	56.3	35.4
36-H	No	-	3471.5	1953	-	-	-	-	-	-	-	-	64.2	69.7	56.0	45.5
Township 22 South, Range 14 East																
31-L	No	105	3483.0	1940	-	77.0	-	88.3	89.1	87.2	86.7	-	92.0	92.5	-	83.7
Township 23 South, Range 13 East																
1-F	No	-	3439.7	1955	-	-	-	-	-	-	-	-	-	-	28.5	6.3
1-I	Yes	130	3451.3	1946	48.5	-	-	48.0	41.9	-	-	46.5	-	50.1	30.6	9.3
1-J	No	88	3447.6	1945	46.0	-	-	47.2	40.9	-	-	45.5	-	49.2	34.2	-
1-K	Yes	260	3447.0	1946	49.2	-	-	-	42.5	45.6	40.7	46.6	47.5	50.7	-	-
1-K	No	-	3444.4	1945	46.4	-	-	47.6	42.6	-	-	45.2	46.8	50.2	31.3	9.1
1-P	No	83	3458.2	1940	-	11.4	-	39.0	32.8	35.2	32.5	38.6	38.3	41.0	25.5	6.6
10-C	No	-	3567.0	1953	-	-	-	-	-	-	-	-	225.3	226.6	227.4	226.5
12-G	No	-	3459.7	1953	-	-	-	-	-	-	-	-	37.2	41.7	25.7	8.0
12-P	No	-	-	1939	22.1	21.3	30.8	30.3	29.9	27.5	28.9/	-	-	-	-	17.3
13-H	No	37	-	1940	18.7	-	20.3	19.9	20.5/	-	-	-	-	-	-	-
Township 23 South, Range 14 East																
16-E	No	-	-	1948	-	-	-	11.1	10.4	11.6	9.7	12.9	-	13.2/	-	-
16-O	No	-	-	1942	32.5	-	32.3	-	30.3	31.4	31.6/	-	-	-	-	-
16-P	No	-	-	1948	-	-	-	10.1	9.2	9.4	9.3	11.1	11.7	12.2	8.7	8.3
17-A	No	-	-	1940	-	14.5	-	18.2	15.3	14.7	13.0	20.4	20.4	20.0	13.9	14.3
19-E	No	22	-	1940	-	10.1	12.6	13.3	-	12.6	11.1	11.7	11.0	13.3	8.2	8.6
21-H	No	50	-	1939	20.5	20.4	22.4	22.5	21.7	-	-	-	-	-	-	-
22-D	No	45	-	1940	-	27.8	-	28.9	28.8	28.2	29.3	30.3	29.6	30.3	27.5	-
22-O	No	-	-	1940	-	12.9	-	-	12.8	13.3	14.0	15.3	15.1	15.1	13.6	13.6
22-P	No	25	-	1940	-	8.8	-	-	9.8	9.7	9.5	12.4	12.2	11.8	8.8	8.7
25-D	No	48	-	1940	-	26.4	-	45.5	47.0	42.0	40.9	45.5	44.1	45.5	38.0	22.9

Location in Township	Log on File	Depth in Feet	Measuring Point Elevation	Depth to water in feet from measuring point, at approximate ground surface: First record Year	First record Depth	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
									Township 23 South, Range 14 East (continued)							
25-N	No	42	-	1939	21.7	19.5	42.2	44.3	34.9	-	-	-	-	-	-	-
26-D	No	-	-	1948	-	-	-	16.4	13.0	13.0	12.7	17.3	16.3	16.5	10.4	4.6
26-J	No	-	-	1940	-	18.6	-	36.8	31.9	31.6	31.5	37.9	36.4	36.6	26.0	18.3
26-L	No	17	-	1940	-	2.3	-	-	-	15.0	13.3	19.5	18.6	-	9.7	4.6
26-P	No	35	-	1939	21.0	19.0	32.1	30.0	29.1	26.8	33.3/	-	-	-	-	-
27-A	No	-	21	1940	-	14.8	-	20.4	25.2	18.3	16.5	19.2	19.9	20.1	15.1	14.6
27-B	No	-	-	1952	-	-	-	-	-	-	-	21.5	20.9	-	13.6	12.1
27-C	No	36	-	1939	18.4	18.0	18.0	18.6/	-	-	-	-	-	-	-	-
27-H	No	-	-	1939	20.9	23.3	-	-	-	-	-	-	-	-	-	-
30-D	No	-	-	1939	18.7	18.0	13.7	-	19.6	19.8	20.1/	-	-	-	-	-
30-C	No	-	-	1946	19.0	-	-	17.1	-	18.8	19.1	19.2	19.6	19.7	19.7	20.3
30-N	No	26	-	1939	2.8	.2	.7	.8	.2	.7	-	-	-	-	-	-
31-G	No	-	-	1949	-	-	-	-	21.8	16.6	-	15.1	14.1	15.3	12.2	10.7
31-I	No	-	-	1940	-	25.3	-	31.8	-	-	24.9	26.2/	-	-	-	-
32-N	No	-	-	1953	-	-	-	-	-	-	-	-	24.1	26.8	19.0	14.6
36-D	No	52	-	1939	18.5	16.8	26.1	38.1/	-	-	-	-	-	-	-	-
36-E	No	65	-	1940	-	2.0	-	34.6	14.0	19.2	25.7	32.1	28.2	32.6	9.7	7.1
36-N	No	17	-	1948	-	-	-	23.1	11.7	9.4	14.5	20.0	16.1	24.9	7.5	7.1
36-O	No	17	-	1940	-	5.7	-	20.0	8.5	6.3	11.4	16.8	12.9	-	-	-
									Township 23 South, Range 15 East							
31-P	Yes	67	-	1940	-	11.5	-	30.0	19.5	11.7	21.1	24.4	-	34.5	11.0	10.3
									Township 24 South, Range 14 East							
5-I	No	39	-	1940	-	22.2	-	31.3	-	25.0	23.9	21.4	25.2	28.5	23.4	19.6
5-P	No	-	-	1940	-	21.0	-	28.0/	24.7	22.1	22.9	19.0	-	28.5	-	-
8-G	No	35	-	1939	19.5	20.8	18.0	24.8	-	-	-	-	-	-	-	-
									Township 24 South, Range 15 East							
7-G	No	-	-	1940	-	11.7	-	8.4	7.2	7.3	7.4	7.7	7.0	7.7	6.5	6.5
7-O	No	14	-	1940	-	7.6	-	7.8	7.0	7.9	7.6	7.3	7.2	7.2	7.3	7.2
18-B	Yes	45	-	1940	-	10.3	-	-	-	11.3	11.0	10.7	-	10.6	10.7	10.6
18-C	Yes	80	-	1948	-	-	-	9.8	-	11.1	10.8	10.2	10.0	10.3	10.1	10.1

The ground-water contour map is a most important tool in the analysis of ground-water conditions. It furnishes information as to the source of supply, the direction of flow, probable location of structural changes in the ground-water basin, variation in permeability and the extent of the ground-water reservoir, and areas of withdrawal or discharge from the basin.

Maps Showing Changes in Ground-water Levels

The cumulative effects of lowering water levels are shown on the maps by lines of equal lowering in Plate II for the period 1947-56 for the area in Pima County and in Plate IV for the period 1940-54 for the area in Santa Cruz County. In many parts of the basin the exact amount and extent of lowering, particularly in the fringe areas, can only be estimated. Normally the water levels which most nearly represent residual losses to the water table are those of the late winter or early spring after the wells have recovered from the effects of the previous summer's pumping.

Occasionally a single season of sustained high rainfall with resulting flood flows is sufficient to provide enough recharge in parts of the basin to more than replace the accumulative losses of several years. This is illustrated by the recovery shown on the map in Plate V for the period between 1954 and 1956 for the portion of the valley in Santa Cruz County. The volumetric depletion of a ground-water reservoir can be computed from water level lowering maps. However, to make an accurate quantitative estimate of the amount of water withdrawn from storage, requires a weighted average value of the specific yield of the formations unwatered, which usually is based upon extremely limited data. Earlier studies indicate that the specific yield for the Santa Cruz basin as a whole is not more than ten percent. These studies indicate that, in general, the specific yield of the recent formation on the bottom land is higher than that of the Quaternary which comprises the major part of the valley fill.

From the ground-water lowering map (Plate II) it has been estimated by using a specific yield of ten percent that there has been somewhat more than 300,000 acre-feet of water removed from the ground-water reservoir in the 9-year period. No account was taken of the areas where the loss was less than 5 feet, because it is impossible to draw the line of no change.

Profile Maps Along the Santa Cruz River and Rillito Creek

To better visualize the changes which have taken place in the water table at various times over a period of years as the result of pumping, longitudinal profiles have been constructed along the trough of the Santa Cruz Valley and of Rillito Creek. The profiles thus pass through the centers of the most concentrated draft and likewise show the maximum effects of recharge from flood flows in the stream channels. A small strip map of each section is shown above the profiles to facilitate their location. Each section of the profile map is lettered to correspond with the location of its center line as shown on the ground-water contour maps in Plates I and III.

The profiles along the Santa Cruz River for the following sections are shown: between Rillito Station and the San Xavier Mission in Figure 4, San Xavier Mission to Santa Cruz County line in Figure 5, and from the Santa Cruz County line to the junction with Nogales Wash in Figure 6. The profile along Rillito Creek is given in Figure 7.

QUALITY OF WATER

by

H. V. Smith[11]

Water without some matter in solution is never found in nature. Rain drops as they form in the sky combine with the gases and dust of the atmosphere so that by the time they reach the earth they contain a variety of impurities, oxygen, nitrogen, carbon dioxide and mineral matter. After rainwater reaches the earth's surface and comes in contact with rocks and soil, some may run on the surface as stream flow, while some may soak into the ground. In either event, it dissolves such water soluble impurities with which it comes in contact. In the Southwest, surface stream flow may never reach the ocean, but instead may seep into the stream channel and move below the surface. If the media through which this water is passing is porous and the amount of water and time is great enough, this underground flow reaches and recharges the water table. If the amount of water available at the surface is small, it may be retained there and used by vegetation or lost by evaporation. The nature and amount of the soluble material present in the ground water is related to the source of the rocks and minerals through which it has passed, and the amount of leaching and the permeability of the various strata of soil.

If the parent rocks are dominantly sedimentary in nature such as sandstones, shales or limestones, the ground waters associated with them are likely to contain more salt than from such volcanic rocks as granite or rhyolite, etc.

As underground water moves down a valley, its salt content tends to increase. Because water cannot mix underground, the source of ground water may often be predicted from a chemical analysis of the water.

In evaluating the quality of waters for different uses, certain standards have been set up by which the waters can be rated. Domestic waters have different standards than industrial or irrigation waters.

Domestic waters should have a low soluble salt content, be soft in nature and have a low fluorine content. Waters to be used in boilers or coolers should have a low calcium content so that scale will not form in objectionable amounts. Water which is used for irrigation should have a relatively low salt content and have a low sodium:calcium ratio, preferably less than one part sodium for each part calcium in solution.

Domestic Waters

Approximate limits of dissolved salts in waters may be set in grouping waters into categories of varying degrees of quality. Three characteristics should be considered in rating domestic waters for quality. The first factor is the soluble salt content. If this exceeds 700 to 1000 parts per million the water will have a slight taste, more noticeable as the salt content increases. In spite of the taste, waters whose salt content exceeds 2000 parts per million are used for drinking without any apparent adverse effect on the body.

The second factor to be considered in rating domestic waters is their hardness. Table 5 [12 13] gives the relative hardness of waters. Soft waters are desired, because they consume less soap and leave less scale in hot water boilers and cooking utensils.

[11]Professor of Agricultural Chemistry and Soils.

[12]SMITH, H. V., Caster, A. B., Fuller, W. H., Breazeale, E. L. and Draper, George, The Chemical Composition of Representative Arizona Waters, Bul. 225, Arizona Agricultural Experiment Station, University of Arizona, 1949.

[13]WRIGHT, F. B., Rural Water Supply and Sanitation, John Wiley and Sons, New York, New York.

Table 5. – RELATIVE HARDNESS OF WATERS[12]

Hardness g.p.g.	Pounds Soap Used By 1000 Gallons Water	Relative Hardness
0.0 – 4.5	0 – 6.8	Soft
4.5 – 9.0	6.8 – 13.5	Fairly hard
9.0 – 15	13.5 – 22.5	Hard
15 +	22.5 +	Very hard

The presence of calcium and magnesium in water is the cause of its hardness. These elements combine chemically with soap which causes an undesirable curd to form in the water before suds can form.

The third factor to consider is the fluorine content. The continued use of water containing more than 0.8 parts per million of fluorine by children, under the age of 12, in Southern Arizona will produce mottling of their permanent teeth. The water must be used for several weeks before enough fluoride, depending on concentration, will be ingested to noticeably stain the teeth. The alteration of the tooth structure occurs during the period of formation and before eruption through the gum. However, a fluoride content of 0.5 – 7 p.p.m. is considered desirable to insure a hard enamel. Naturally, some allowance must be made for the activity of the child and other factors which may vary the quantity of water used from the normal.

Table 6 shows the degree of mottling produced by various concentrations of fluorine in Southern Arizona.[12]

Table 6. – SEVERITY OF MOTTLED ENAMEL PRODUCED BY VARYING AMOUNTS OF FLUORINE IN DRINKING WATER.[12]

Amount of Fluorine p.p.m.	Severity of Mottling
0.0 – 0.8	None
0.9 – 1.3	Mild
1.4 – 2.0	Moderate
2.1 – 3.0	Moderately severe
3.1 or over	Severe

Irrigation Water

Irrigation waters, like domestic waters, are most desirable if they contain a low salt content, since waters which are high in salts are toxic to plant growth. In addition they should have a sodium:calcium ratio of less than 1.0 because an excess of sodium tends to disperse the soil and thus destroy its structure. McGeorge has classified irrigation waters with respect to quality in the following manner.[14]

Table 7. – QUALITY OF IRRIGATION WATERS WITH RESPECT TO SALT CONTENT[14]

P.P.M. of Salt	Quality of Water
0 – 500	Very good
500 – 1000	Good
1000 – 1500	Fair
2000 +	Poor

[14]McGEORGE, W. T., Interpretation of Water Analyses, Extension Circular No. 107, Agricultural Extension Service, University of Arizona, 1940.

Since not all ions are as toxic to plants as others, he has suggested the following limits for the chloride and sulfate ions, Table 8. McGeorge states further that traces of carbonate are undesirable because it shows black alkalinity. Bicarbonates are usually considered to be of secondary importance.

Table 8. – QUALITY OF IRRIGATION WATERS WITH RESPECT TO CHLORIDE AND SULFATE CONTENT.[14]

P.P.M. of Chloride	P.P.M. of Sulfate	Quality of Water
0 – 175	0 – 350	Good
175 – 290	350 – 600	Fair
290 +	600 – 900	Poor

Investigators at the U. S. Regional Salinity Laboratory, Riverside, California,[15] have integrated the effects of the salinity hazard and the sodium hazard in classifying irrigation waters.

For example, if a water has a low total soluble salt content a higher sodium percentage is permissible than if the water had a higher total soluble salt content. Likewise a water may be used for irrigation if it has a relatively high salt content and a low sodium percentage. If, on the other hand, a water contains both high total salts and a high sodium percentage, poor crop growth can be expected because of the toxicity of the salt and because of the deterioration of the soil structure.

The decision to use water of questionable quality for irrigation should be conditioned by several factors, such as the amount of water to be used per acre, the texture of the soil, the presence of relatively impermeable layers in the soil, kind of crop and the ability to keep the salts moving downward in the soil rather than to let them concentrate in the root zone.

The farmer should also consider that calcium from a calcareous soil might offset some of the undesirable effects of sodium. If calcium from this source is not sufficient, the addition of gypsum may produce the desired effect.

The Department of Agricultural Chemistry and Soils have several thousand published and unpublished analyses of water in their files (See footnote 12) covering almost every part of the basin. These data have been coordinated and plotted by the Agricultural Engineering Department. (Plates VI and VII)

INDIVIDUAL GROUND-WATER AREAS

The entire Santa Cruz ground-water basin has been divided into major and minor sub-divisions for the purpose of describing the ground-water conditions in individual areas.

CORTARO – CANADA DEL ORO DISTRICT

This is the northern end of the Santa Cruz ground-water basin lying north of Rillito Creek between the Santa Catalina Mountains and the Tucson Mountain foothills.

Cortaro Bottom Land

From the standpoint of water development, the Cortaro bottom land, extending from the junction of Rillito Creek and the Santa Cruz River, is the most interesting area in the ground-water basin. It has been subjected to almost continuous

[15]United States Salinity Laboratory Staff, Diagnosis and Improvement of Saline and Alkali Soils, Agricultural Handbook No. 60, United States Department of Agriculture, pp. 69-82, 1953.

heavy pumping since 1920, by the Cortaro Project and its predecessors.

This area is the nearly level portion of the valley adjacent to the channel of the Santa Cruz River downstream from Rillito Creek. It may be identified by the siltier soil and most of it has been cleared for farming, though not all is cultivated at present. On the west side there are steep bluffs of rocky soil, for about three miles north of the Rillito Creek. Then the bottom land is wider and little of the benchland remains. The escarpment does not lose its identity on the east side, except in the last two miles on the north end. The escarpment apparently extends under the bottom land near Rillito Station and is formed at this place of tightly cemented conglomerates through which the Santa Cruz River has cut a deep, narrow buried channel. Wells of large, 200 gpm, capacity have not been found in Sections 4, 5 or 6, T. 12 S., R. 12 E., though several attempts have been made.

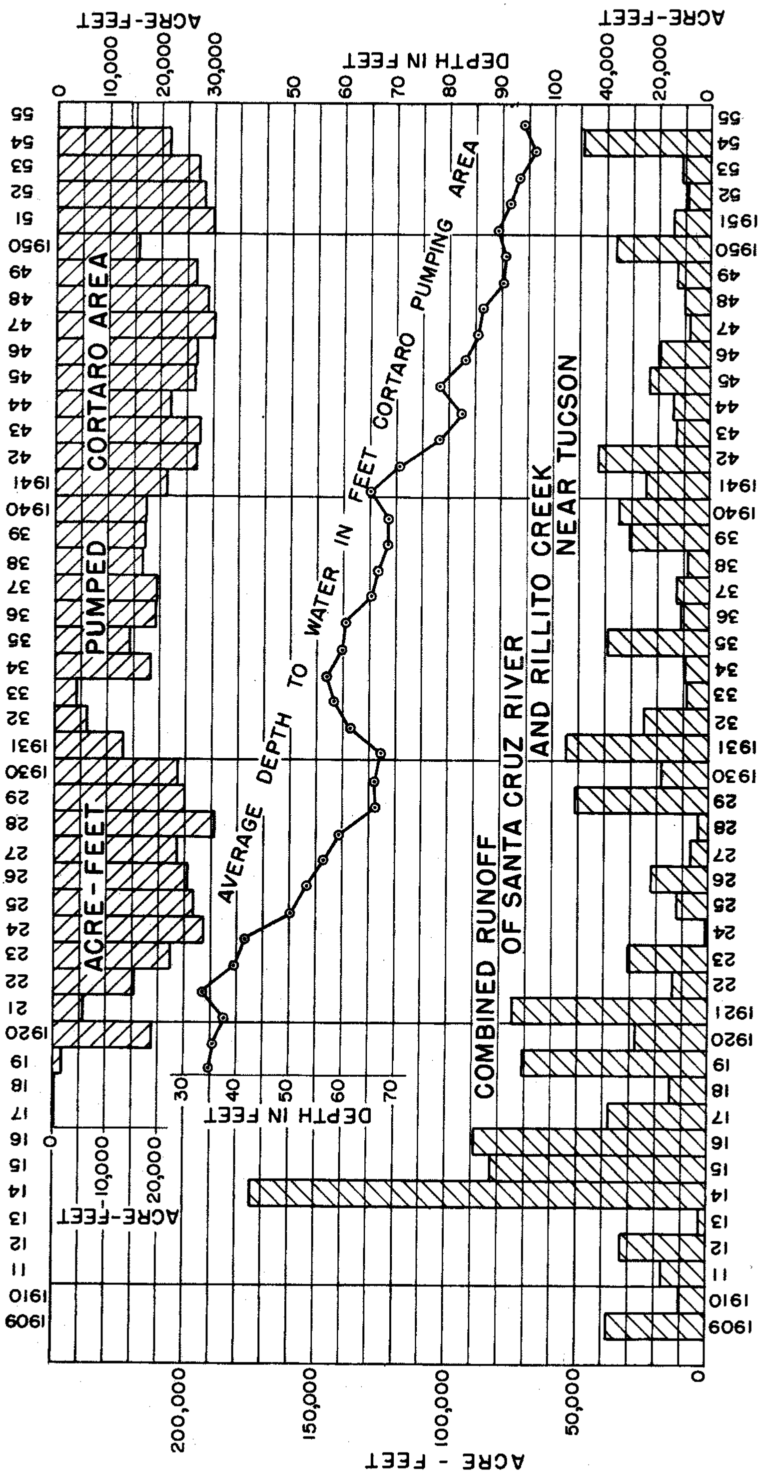
The buried gorge causes a ground-water cataract around the north end of the Tucson Mountains. This is plainly shown on the profile Figure 4, between miles zero and two in which distance the water table falls 140 feet. The surface topography is shown in photograph 11. Under virgin conditions this ground-water fall was 130 feet high between miles one and two of profile line A.

Previous to the project development there had been only a few hundred acres under irrigation in any one year within the entire Cortaro Area. Water table fluctuations were largely in response to variations in the stream flow of the Santa Cruz River and Rillito Creek. It appears probable that the water levels in the area reached a historical high in the Spring of 1915 as the result of the unprecedented flood flows of the 4-month period, December 1914 - March 1915, inclusive. During this short period the combined flow of the Santa Cruz River and Rillito Creek passing Tucson was over 240,000 acre-feet. By mid-summer of 1917 water levels in the lower end of the area, above Rillito, had receded from this high point by as much as 10 to 16 feet.

A comparison of the annual pumping draft, from the Cortaro area, the combined flood flows in the Santa Cruz River and Rillito Creek, and the average water level in the irrigation wells has been prepared. (See Figure 8)

Runoff records are shown for the entire period for which they are available on both the Santa Cruz River and Rillito Creek, 1909-1956, inclusive. The chart does not show the addition to this measured flow from tributary washes and the Cañada del Oro which enter below the gaging stations and normally do not contribute much water. However, occasional floods of short duration may be expected from the Cañada del Oro as shown by the three short-lived flows in a period of five days with a total estimated runoff of 7,000 acre-feet in the period July 28-August 1, 1921, and two peaks of about 8,000 second feet. Although no actual records are available, it is certain that there has been no other comparable flow at least since 1919.

Considering only the total flood flows, the opportunities for recharge from channel seepage vary widely between the minimum of 1,240 acre-feet in 1924 and the maximum of 174,000 acre-feet in 1914, of which 162,000 acre-feet occurred in December. The average combined flow of the two streams for the entire period of record is less than 29,000 acre-feet per year. The maximum average combined annual flow for a 10-year period was almost 62,000 acre-feet for the period 1914 - 1923, inclusive, and the minimum for a 10-year period was less than 16,000 acre-feet during the period 1942-51, inclusive.



Bar graph of combined annual flow Santa Cruz River and Rillito Creek at Tucson, compared with pumpage and average water level in Cortaro Area.

FIGURE 8

The water level curve in Figure 8 is the result of plotting the average of the Spring water level measurements from a group of 12 wells, selected to give a weighted average position of the water table for the entire pumping area. The curve therefore represents the highest position of the water table for each year. The change from one year to the next shows the combined effect of the previous year's pumping, recharge from flood flows and ground-water inflow from the sides and upstream. The high point in the Spring of 1922 probably differs but little from the average water level prior to any project pumping.

The average water level curve is most closely correlated with the pumping of the previous year. However, the favorable effects of the recharge from floods is clearly shown by the decreased rate of lowering or even a rise following the years of exceptionally heavy runoff.

Representative of the seasonal fluctuations and also the cumulative effects of the pumping in the Cortaro area is the continuous water level chart shown in Figure 9. The record shows the water level changes close to the Santa Cruz River in Section 16, Township 12 South, Range 12 East. The fluctuations may be most closely correlated with the daily pumpage of the Cortaro Water Users' Association. The curve of the water level shows the effect of seasonal demand for irrigation water in response to the kind of crops grown as well as total annual use. Particularly prominent is the immediate response to the reduced pumping during the depression years of 1931-33, inclusive, in which the rise between the Spring of 1931 and that of 1934 was approximately 16 feet.

Plotted in the same figure for comparison is the longest water level record available from a well on the bajada, or valley slope, in the northeast corner of Section 18, Township 12 South, Range 13 East. This well is about 3½ miles from Cortaro and it is doubtful if lowering of any consequence prior to 1935 had occurred. Careful examination of the curve of water level lowering at this well shows that since 1935 there has been a consistent, gradual and slightly accelerating rate of lowering in the water level. The amount of pumping in this area would not be expected to have any appreciable effect on the water table. Based upon the evidence of water levels from wells such as this, it may be assumed that the pumping over a long period of years is not only unwatering the ground-water reservoir immediately adjacent to the pumping area, but also is gradually drawing upon a continually widening area of influence.

The cumulative effect of pumping along the trough of the valley in the Cortaro area is best illustrated by the longitudinal profile of the area shown in Figure 4. The original position of the water table, prior to any significant amount of pumping, and its position in the Spring of 1940, 1947 and in 1954, 1955 and 1956 is shown. An average lowering of about 65 feet from one end of the pumping area to the other is indicated. There has been continuous pumping for a period of 36 years with a total withdrawal from this area of 750,000 acre-feet of water, or an average 20,800 acre-feet per year.

The residual lowering in the water table for the 9-year period 1947-56 is shown on the map in Plate II. The map emphasizes the marked effect of the location of the most recent centers of pumping development. The lowering map shows the effect of draft in the Tucson area upon the Cortaro area and there is indication of possible recharge from the effluent of the Tucson Sewerage plant.

The ground-water contour map in Plate I indicates that there are two general sources of ground-water inflow to the Cortaro area. Underflow from the main

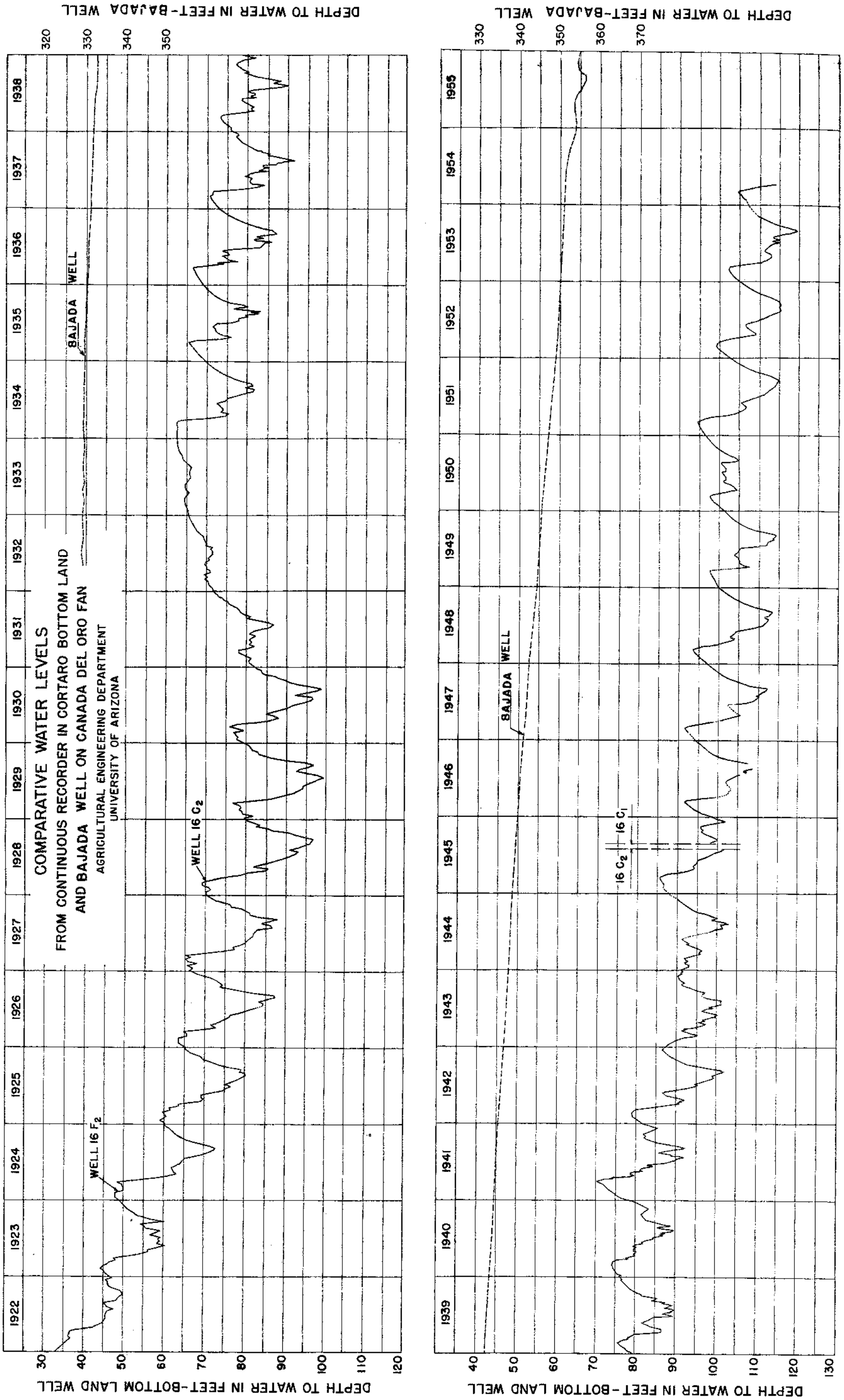
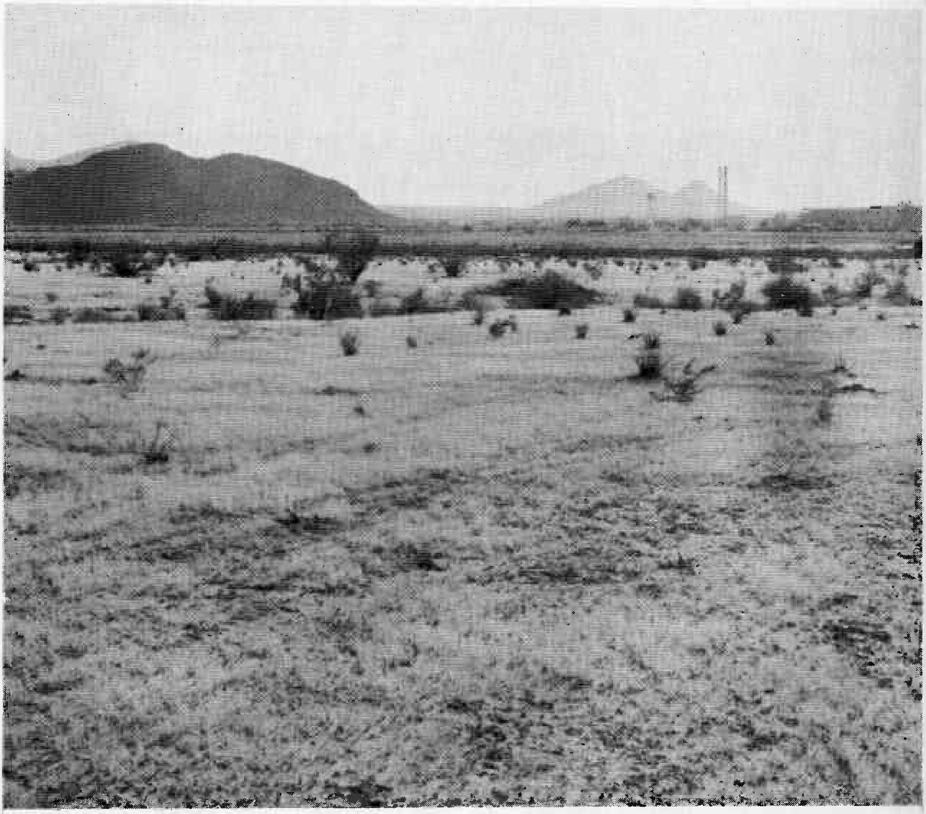
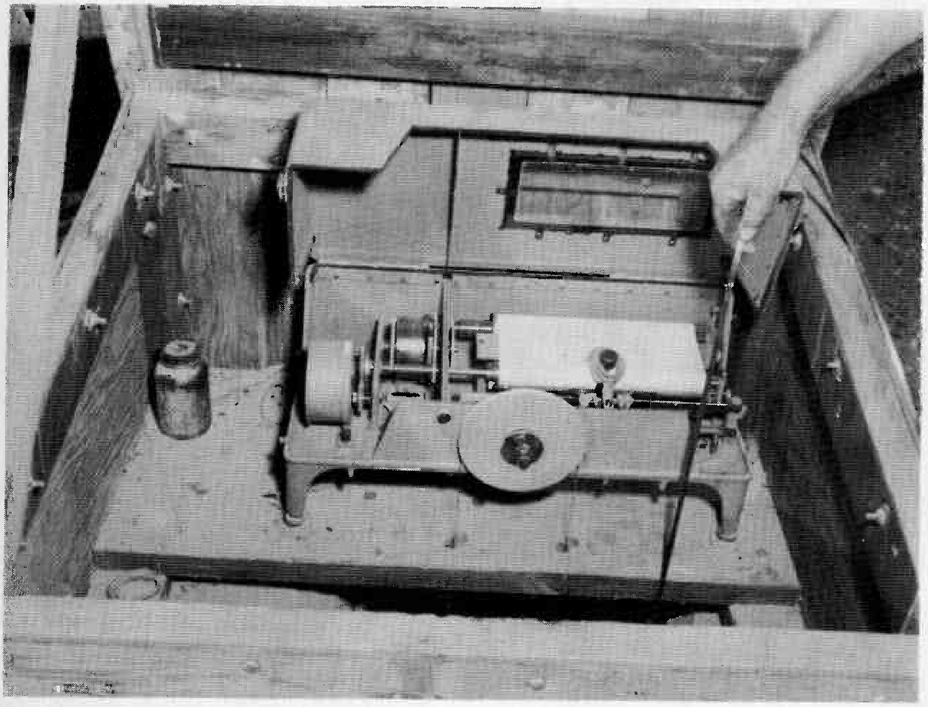

COMPARATIVE WATER LEVELS
FROM CONTINUOUS RECORDER IN CORTARO BOTTOM LAND
AND BAJADA WELL ON CANADA DEL ORO FAN
AGRICULTURAL ENGINEERING DEPARTMENT
UNIVERSITY OF ARIZONA
DEPTH TO WATER IN FEET-BAJADA WELL
DEPTH TO WATER IN FEET-BOTTOM LAND WELL
WELL 16 F2
WELL 16 C2
BAJADA WELL
16 C2
16 C1

FIGURE 9



PHOTOGRAPH 11

Photograph of Rillito Station (extreme right) shows point of mountain (on left). Groundwater fall is between point of mountain and Arizona Portland Cement Company Plant. There is no hint on surface of this discontinuity in water table. Photo by Walker Bryan.



PHOTOGRAPH 12

Continuous water level recorder on unused irrigation well near Cortaro. A recorder has been in operation in this area for 35 years. Photo by John Burham.

valley of the Santa Cruz combined with that from Rillito Creek comes in from the southeast and the Cañada del Oro is a source of recharge from the northeast. The ground-water contours approach both the Tucson Mountains and the Tortolita Mountains nearly at right-angles, an indication that ground-water flow from them is of little consequence. The other important source of recharge in addition to underflow coming into the area is the recharge from flood flows by seepage in the stream channels. Return flow from seepage in irrigation and from over-irrigation is not believed to be an important factor, although the seepage from the increasing amount of effluent of the Tucson Sewerage Plant is becoming so. A large part of the water pumped in the Cortaro area has for many years been transported downstream to the better quality farming lands in the vicinity of Marana, to the northwest.

A comparison of the ground-water contour map (Plate I) with the chemical analysis map (Plate VI) shows the demarcation between the underflows of Rillito Creek and the Cañada del Oro with that from the main Santa Cruz Valley. The last with comparatively high sulfate content and hardness differs greatly from the former two supplies. Particularly is this true of the Cañada del Oro underflow which has the lowest soluble salt content of any waters in the Upper Santa Cruz Valley.

Cañada del Oro Fan

This area lies between the Tortolita and Catalina Mountains and includes the valley slope east of the Cortaro bottom land. This excellent example of a bajada may be found east of Cortaro where the slopes from the Tortolita's on the north have been cut through by the Cañada del Oro Wash. The ground-water flow originating in the Cañada del Oro drainage moves almost due west from a line from the southeast tip of Tortolita Mountains to the west end of the Santa Catalina Mountains. While the gradient of the ground-water surface is quite steep, forty feet to the mile, it is not believed that this gradient is entirely caused by tight formation, but rather because a comparatively large quantity of ground water is in motion. Well measurements made in this area since the early 1930's indicate that the ground-water table is being lowered by the drawdown created by the heavy pumping along the Santa Cruz River. The ground-water lowering a few miles east of the Santa Cruz River is comparatively uniform from year to year, even though there may have been some recovery in wells adjacent to the river.

The Cañada del Oro Wash, west of Oracle Road, has little influence on the ground-water contours except following a year such as 1955. This is probably due to the short duration of the flows. Also, the high permeability of the sand under the fan permits the recharged water to spread rapidly. The surface flow of the Cañada del Oro disappears shortly after the stream leaves the mountains. This combined with limited information from well logs indicates a trough several miles in width and at least 400 feet deep between the Tortolita and Catalina Mountains.

Along the south base of the Tortolita Mountains, excellent examples of both an exposed and buried rock pediment may be found. Rock exposures are very common throughout the north half of the row of Sections 25 to 30 of Township 11 South, Range 13 East, a mile or more from the mountains and wells have encountered bedrock in the south half of Sections 28 and 29. Two wells 600 feet apart in an east and west direction, about a mile south of the exposed rock pediment, in Section 34 encountered bedrock at depths of 578 and 625 feet.

Most wells in the Cañada Fan encountered a sufficient flow to meet the requirements of the suburban homes and small irrigation systems being developed. Irrigation development on the mesa at the west tip of the Catalina Mountains has created a lowering in the ground-water table into which some of the percolating flow of the Cañada is being diverted. The larger farms in the bottom-land of the Cañada have developed wells of several hundred gallons a minute capacity. The ground-water table is very deep under portions of the area and this has discouraged development of large quantities of water for irrigation. Naturally, the closer to the mountains a well is drilled the more the chance of hitting rock above the water table which will result in a dry hole or very poor well. The water is of excellent quality throughout the Cañada del Oro area.

TUCSON METROPOLITAN DISTRICT

The broad central portion of the Santa Cruz Valley in the center of which Tucson is located has been designated as the Tucson Metropolitan District. It extends from the Tucson Mountain foothills on the west to the base of the Rincons on the east and from the Catalina foothills on the north to the San Xavier Mission on the south, and includes a portion of the desert area southeast of the City.

Tucson Mountain Foothills

This area lies west of Silverbell Road, north of "A" Mountain and is mostly rolling hills from an old bajada. The area is developing with suburban homesites and, in most parts, a water supply sufficient for domestic purposes has been secured from small drilled wells. The area is spotted, however, and some wells encountered older valley fill and have furnished water insufficient even for this use. There are indications that the underflow of the Santa Cruz extends for a mile or more beneath the mesa land on the west and possibilities for larger capacity wells are best near the river. Immediately below the base of the mountains, water possibilities are limited with well drillers reporting meager water supply and dry holes. Wells of limited capacity have been drilled in the rock formations, but the supply is dependent upon the encountering of fractures in the rocks.

The water in the area is characterized by relatively high salt content and considerable hardness. (See Plate VI). Due to this, and the limited supply, parts of the area are now furnished domestic water by the City of Tucson and domestic water companies with wells in or near the bottom land.

Jaynes-Flowing Wells Area

This area consists of the portion of the valley lying northwest of Tucson between the Santa Cruz River and Rillito Creek. Most of the land is comparatively smooth and was easily prepared for irrigation. Prior to 1912 there was limited irrigation development in this area. There were a few small pumping plants and gravity water diverted from the Santa Cruz River opposite "A" Mountain was the principle source of supply. A large part of the farm land was acquired by the Tucson Farms Company in 1912-13.

Increased areas were developed for irrigation by this company. The water supply was increased by a Cross-Cut[16] in the Santa Cruz Valley above, and an additional supply was obtained from eight wells drilled within the area. Diminishing supplies of gravity water from the Cross-Cut and the washing out by flood waters of part of the delivery system led to its abandonment in the early 1940's. Since then, entire dependence for a water supply has been upon wells, and in 1951 the

[16]HINDERLIDER, M. C., Irrigation of Santa Cruz Valley, Engineering Record, Vol. 68, pp. 200 and 242, 1913.

Flowing Wells Irrigation District sold the Cross-Cut to the City of Tucson.

Much of the area has since been converted to suburban and industrial use and the irrigated acreage reduced to less than one-half of the maximum. The Flowing Wells Irrigation District is now supplying domestic water to users within its boundaries. Soon its principal activity will be that of a domestic water company.

The accumulated lowering from virgin conditions to 1947 was a maximum in the lower northwestern end of the area, amounting to 35 feet, and in the upper end of the area about 20 feet. Since 1947 the situation has been reversed and the greater lowering has occurred immediately adjacent to the City of Tucson. The accumulative lowering between 1947 and 1956 varies from 35 feet to a minimum of 20 feet in the north end of the area. (See Plate II) Thus the accumulative lowering in water levels up to the spring of 1956 has amounted to 60 feet for the entire area.

The quality of water in the area varies widely from place to place and ranges from poor to excellent. (See Plate VI) A large part of the area has a ground-water supply with higher salt content and greater hardness than is desirable for domestic water. With increasing depth to the water table and the unwatering of the surface water strata there is some evidence of some improvement in quality.

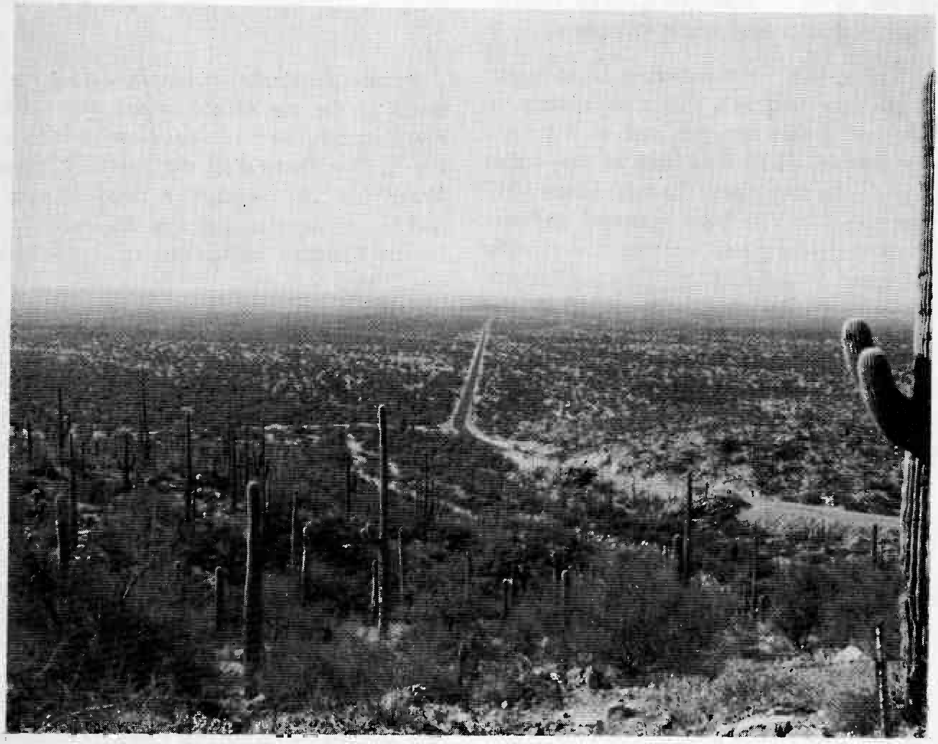
Catalina Foothills and Tanque Verde Area

The area between the Catalina Mountains and the Rillito Creek bottom lands is mostly a deeply dissected bajada or slope of the Pantano formation. See Section on "The Ground-Water Basin" p. 12. Many wells have been drilled into it usually developing a very meager supply or none at all. Some encounter a small pool with little recharge and a good supply at the start, but these eventually fail. Other wells found buried channels or ground-water arteries and resulted in fair domestic wells. There appears to be a zone at the base of the mountains in which water can be developed by drilling through the "red beds". This zone extends less than a half-mile from the rock exposures. Even this close to the mountains, dry holes sometimes results. Photographs 7, 8 and 9.

Further from the mountains and as far south as the toe of the bajada there are few successful wells except close to Sabino Creek. The channel of the Agua Caliente Wash has not scoured a deep channel and has no aquifer under it. As elsewhere in the Pantano formation, an occasional small well is found.

This formation extends under the Tanque Verde Wash and along the north slope of Tanque Verde Ridge to Sahuaro National Monument. The Tanque Verde Wash has cut a narrow valley in the Pantano formation not over a quarter-mile in width. Subsequent deposition or refilling with Recent material furnishes this area with an excellent but shallow aquifer of small capacity — not over 50 feet maximum depth. The demand for irrigation and domestic use results in a marked lowering in the water table during dry periods. However, the ground-water reservoir is quickly refilled in seasons of ample rainfall by surface flow in the Tanque Verde Wash. Photograph 14.

Between Tanque Verde School and the mouth of Sabino Creek the Tanque Verde bottom land has a shallow aquifer with a depth to water of about 30 feet. At least one well with a capacity of 1000 gpm has been developed in this area, but in general only small capacity wells may be expected. Most of the land is in small holdings of the suburban home type and are more than adequately served. This aquifer extends to the north of the Tanque Verde Wash and Rillito Creek, probably



PHOTOGRAPH 13

Mount Lemmon Highway looking towards Tucson from base of Santa Catalina Mountains. Photo 7 is in cut where road disappears in distance. Small hill beyond Road in distance is of Pantano formation. Photo by John Burnham.

following a series of old channels. There are little surface indications to delineate the northern limits of the aquifer. This aquifer will probably be the supply for future suburban development to the north.

The ground-water contours indicate the flow leaves the Tanque Verde about opposite the village and presumably follows an old channel as far south as Broadway. (See Plate I) The water eventually cascades into an inner basin around Tucson.

There are a few small springs at the contact between the base of the mountain rock and the Pantano formation. The two largest springs in the area are Agua Caliente Spring, just south of the wash of the same name, and the Cebadilla Spring on the north bank of Tanque Verde Wash.

In general the water, where found in any quantity, in the Catalina Foothill and Tanque Verde Area is of excellent quality and is locally known as Rincon Water. However, as has been previously mentioned, wells located in the red beds or Pantano formation often encounter water of unsatisfactory quality, it being hard and of high salt and fluorine content. (See Plate VI) Water should be analyzed before any plans for its use are made.

Rincon Foothills and Rincon Creek

East of the ground-water cascade marking the inner basin the water table is uniform with a normal slope up to the east edge of Range 15 where a greater ground-water fall is encountered at a height of approximately 125 feet. (See Plate I) On the upper side a few wells of low capacity have been found. Some have also been failures.

On the southside of Tanque Verde Ridge is Rincon Creek, a half mile wide valley emptying into Pantano Wash. It lies entirely above this big groundwater fall and has a fair aquifer at 160 feet. There is also a shallow perched table in Rincon Creek. Thus, two wells a few feet apart of different depths may have water levels differing by over a hundred feet. The upper or perched table is a poor source and occasionally fails. Five wells have been developed for irrigation on the south side of Rincon Creek. The quality of water is excellent.

In general, the quality of water in the Rincon Foothills is the same as in the Catalina Foothill-Tanque Verde Area. (See page 83). (Plate VI)

Inner Basin

The City of Tucson and much of the adjacent metropolitan area overlie a groundwater basin within a basin. The location of the horseshoe shaped boundary of the inner basin is indicated on the Key Map (Figure 1) and is marked by the band or zone of closely spaced contours on the Ground-Water Contour Map (Plate I). In places the steepness of the slope of the water table along this boundary warrants the use of the term ground-water fall. For example the ground-water fall across the contours is 70 feet in less than one-quarter mile at the common corner of Sections 4, 5, 8 and 9, Township 14 South, Range 15 East. From this point the boundary line, or zone, trends northwest toward the junction of Pantano Wash and Rillito Creek. The area at the junction is underlain at shallow depth with relatively impervious clay and conglomerate which diverts the underflow of Rillito Creek to the southwest, away from the stream channel. The boundary ~~of~~ the inner basin trends southeast from the aforementioned section corner for about two miles and then turns to the southwest toward the northeast corner of Township 15 South, Range 14 East. Thence it follows a westerly course along the north edge of this township and as it approaches the Santa Cruz River its trend is southwesterly.

Significant lowering of five to ten feet (1947-1956) in the water table has extended to the boundary of the inner basin. The ratio of the lowering inside the basin to the total fall across the boundary

PHOTOGRAPH 14

Ground surface over ground-water cascade into Inner Basin. Tank in background, about 700 feet away, is on low side of cascade, while tank in foreground is on high side. There is nothing on the surface to indicate a change underground. Photo by John Burnham.

zone, however, has been small, and the rate of ground-water flow into the basin has not been materially affected as yet. A small amount of lowering upstream or outside of the inner basin has occurred, but this may, at least in part, be attributed to the prolonged drought since 1941.

There are no surface topographic features to identify the location of the ground-water falls or the boundary zone of the inner basin. It is, in most places, covered by several hundred feet of Quaternary fill and it is probable that the explanation is in the structure of the underlying older valley fill. Logs of wells which are available have not contained the information necessary to provide an explanation for the increased hydraulic gradient of the water table in the boundary zone.

Information obtained from observations while a deep well was being drilled for the Tucson Gas, Electric Light and Power Company, near the center of the northwest quarter of Section 3, Township 15 South, Range 14 East, (see page 22) did not provide a complete explanation. The well is located within the outer edge of the boundary zone, and the surface water was encountered at a depth of 147 feet as was anticipated. With increasing depth the surface water stratum was cut off by the casing and when the well was completed, the casing was perforated only below 240 feet. The static water level was then at 188 feet, which is approximately the same elevation as adjacent wells located within the basin. This condition indicates that the surface water stratum is separated from the deeper strata by a relatively impervious bed or beds of sufficient lateral extent in this area to prevent the free flow of water to them from the surface stratum. Under these conditions the surface stratum must be considered as a perched water table.

A probable explanation for the inner ground-water basin is that the boundary zone or ground-water falls represent the trace of faulting in the older underlying valley fill—possibly Tertiary—or Pantano formation. Downward movement more or less as a block of the inner basin relative to the surrounding portion of the valley with contemporaneous and subsequent filling of the inner basin could have provided a favorable condition for a ground-water aquifer. Displacement of the ground-water horizons within the boundary zone could be sufficient to cause the steeper gradients of the ground-water table.

The comparatively high temperatures and salt content of the water encountered in the bottom of the deep well of the Power Company and the tentative identification of the sample taken from a depth of 810 feet as Pantano formation lend some support to the fault theory. Logs of some wells only a few hundred feet in depth and located in the area close to and above the ground-water falls indicate that formations similar to the older valley fill were encountered. Additional weight is given this theory by the presence of a large number of faults which have been identified in the rock formations immediately adjacent to and within the valley fill.

Rillito Creek Area

This area occupies the narrow bottom land, from one-half to three-quarters mile in width, along Rillito Creek at the base of the Catalina foothills from Oracle Road east to the mouth of Sabino Creek. There was probably irrigation on a very small scale from Rillito Creek by gravity diversion as early as the 1850's. In 1912 there were at least a half-dozen infiltration ditches in intermittent use, one of which is still in operation and is effective in wet years. There were also as many as 25 small, shallow-well engine-driven pumping plants which were operated only part-time, largely to augment the surface diversions or infiltration ditch supplies. Probably the total acreage under irrigation in any one year did not exceed 750 acres at this time.

Rillito Creek presents the finest opportunities for recharge in the entire Santa Cruz drainage area. The wide coarse, sandy streambed absorbs practically the entire winter and spring runoff from snow melt and the extremely permeable Recent valley fill provides for rapid lateral movement away from the stream channel. The alluvial fill which underlies the bottom land provides an excellent ground-water reservoir, but its capacity is limited by its shallow depth particularly east of Pantano Wash. As a rule, the only water which escapes from the basin is that from the short-lived and silt-ladened summer floods. The average annual surface flow into this area from Sabino Canyon alone is about 9000 acre-feet per year from its 35 square mile drainage and the spring flow of 1952 amounting to at least 10,000 acre-feet was completely absorbed within Range 14 East.

The general direction of ground-water movement is westerly, parallel to the stream channel (see Plate I). Direct recharge from stream flow results in a ground-water ridge under the bottom land. The contours show a southwesterly component of flow leaves the areas of maximum recharge, particularly in those sections where the ground-water storage is limited by the shallow depth of Recent fill.

The water levels along the bottom land respond almost immediately to the recharge effects of stream flow and pumping draft. The long term water level curve given in Figure 10 for the University Farm well on North Campbell Avenue gives representative pictures of the seasonal and annual fluctuation as well as the effects of wet and dry periods. This curve and the profile (Figure 7) of water levels along Rillito Creek show graphically the effects of the increased use of water in the area and the remarkable recovery in water levels resulting from the exceptional runoff of 1941.

The profile for spring of 1956 shows but little effect of pumping draft in the eastern end of the area, with minor areas of lowering, the result of the immediately preceding dry period. However, because of the extremely shallow character of the ground-water reservoir the irrigation water

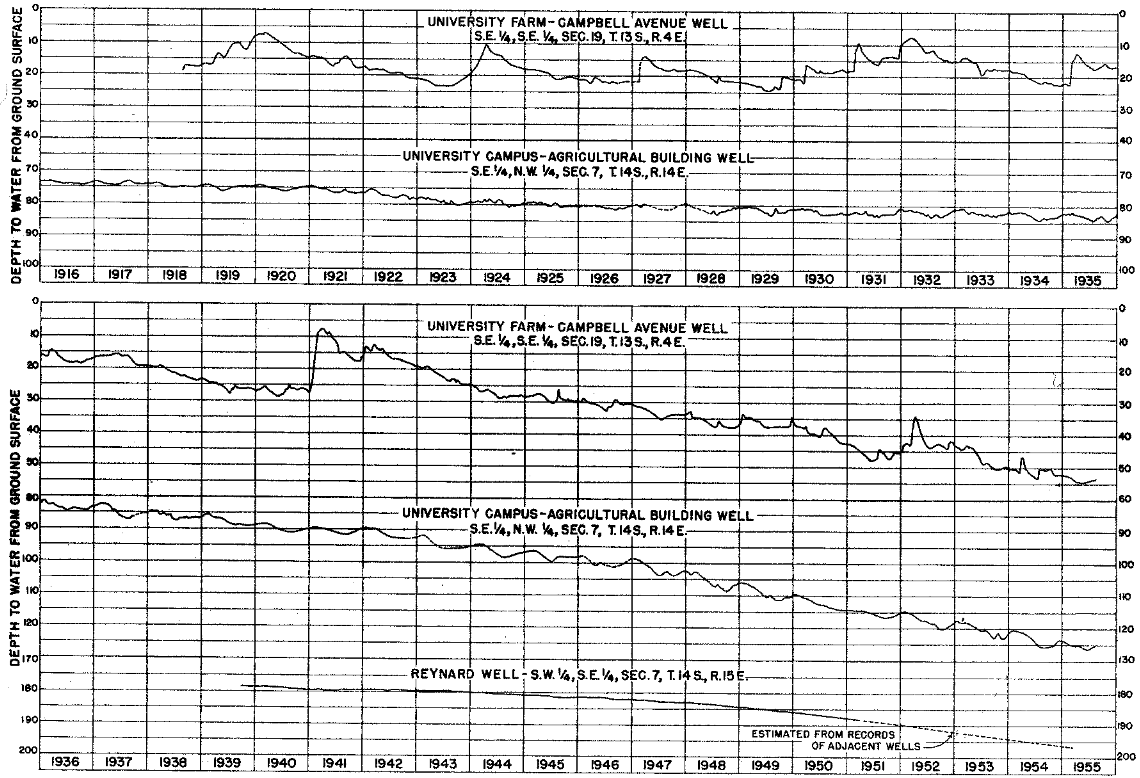


FIGURE 10

Graph of Water Level Records from Three Representative Wells Within the Inner Basin — University Farm Well on North Campbell Avenue, University Campus Well, and a well six miles east of the University Campus.

supply is limited. The profiles and also the water level lowering map (see Plate I) show that residual lowering in the water table amounted to between 55 and 60 feet at Oracle Road, of which over half is the result of the past 9 years pumping.

Present indications are that recharge to this part of the area is insufficient to prevent continued and possibly accelerated lowering. A period of high runoff, similar to that of the winter of 1914-15, will be required before any substantial recovery in water levels may be expected in the west end, near Oracle Road.

Well water from the Rillito bottom land area is considered to be of excellent quality, compared to waters in general use in the Southwest, both for domestic and irrigation use.

The Santa Cruz Bottom Land

At least part of the Santa Cruz bottom land west of Tucson and extending South to the San Xavier Mission was irrigated prior to the Gadsden Purchase in 1853. Up to 1912 irrigation was limited to a couple of thousand acres in the valley. Gravity water from surface diversions and underflow collecting ditches supplied most of the water. Only four small pumping plants were in operation in this part of the Santa Cruz Valley. During 1912 and 1913 most of the bottom land, with the exception of that lying immediately west of the City, was acquired by the Tucson Farms Company as a part of their extensive irrigation and land development project (see page 82). Numerous wells were drilled and land was cleared and prepared for irrigation, but the total acreage under crop in any one year within the area was never more than 3000 acres.

Prior to 1921 the City secured its entire water supply from this area. In 1956 the pumping for irrigation within the area was limited to about 1400 acres and in the Papago Reservation, upstream, to less than 400 acres. In addition the City of Tucson continued to obtain a large part of its water supply from the City Water Farm on the east side of the river.

Records from wells along the Santa Cruz River indicate that previous to 1921 there had been negligible change in ground-water levels due to pumping from the Santa Cruz bottom land and that even in 1930 only a small part of the area showed any significant drop in the water table. The profile, based upon spring water-level measurements along the Santa Cruz River (Figure 4), shows the elevation of the water table under virgin conditions in comparison with its position in 1940, 1947 and in 1954, 1955 and 1956. They reflect most closely the effects of increased pumping from the City Water Farm in the area above "A" Mountain and also show some indications of recharge from the unusually long period of continuous flow in the summer of 1954 and 1955.

Below "A" Mountain the greatest accumulative lowering, amounting to a maximum of 50 feet, has occurred and this has taken place mainly since 1947. This sudden drop has been due probably to, (1) the interception of underflow from the southeast by pumping within the City, (2) the loss of a perched water table which had previously not been recognized, and (3) to a lesser extent, limited recharge from flood flows due to the low permeability of the Santa Cruz stream bed and adjacent valley fill materials.

There is some evidence to indicate that if the Santa Cruz River between "A" Mountain and the San Xavier Mission had a channel in the older alluvium, now deeply buried, it must lie considerably east of the present bottom land. A buried and in some places exposed rock pediment extends from the Tucson Mountains to the east across Mission Road into the bottom land. East of the river and north of Sahuarita Butte in Sections 11 and 14, Township 15 South, Range 13 East, several drill holes have encountered bedrock at depths of less than 100 feet believed to be the top of buried volcanic peaks. Between the pediment and the buried volcanic peaks wells drilled to depths of between 150 and 200 feet encountered tough clays, clays and conglomerate, or in some cases, a conglomerate which carries no water and has the appearance of being a much older formation than those encountered within the Inner Basin.

TUCSON MUNICIPAL WATER SUPPLY

The original Spanish walled City of Tucson was supplied with water from the river and in the event of failure, water was then obtained from shallow, dug wells using a rope and bucket. Undoubtedly there was a cart or pack animal to carry it to the houses as far east as where Stone Avenue is now. There was little change until 1880 when, after one too many serious fires, there was a popular demand for a water system. Probably the advent of the railroad that year, making pipe easier to obtain, was more than a coincidence. The first to make plans for a water system was Mr. Bob Leatherwood, who later achieved fame as a frontier sheriff. He sold his undeveloped system to Sylvester Watts in 1881.

Mr. Watts brought water to Tucson from the Santa Cruz River near the location of the new Valencia Road bridge. He dug a trench in the river bed and buried a redwood flume in the sand as a collector.

Examination of the ground-water Profile Rillito Station to San Xavier Mission, Figure 4, will show a sharp drop between miles 23 and 24. This is the ground-water cascade into the inner basin. Unquestionably this is caused, in this area by the presence of a buried rock pediment, which has been found in several wells drilled in the vicinity. Naturally, there will be a shallow aquifer between the river and the bedrock and prior to the unwatering of the bottom land above San Xavier Mission, this aquifer could not carry all the water flowing down the Santa Cruz River. Therefore, the surplus had to flow on the ground surface.

Probably the river channel was not as deep as now and Mr. Watts had little trouble getting the water out of the river bed by gravity, a mile and one-half south of Irvington Road. Here he had a small settling basin and brought the water to Tucson through a 10″ riveted sheet iron pipe. This gave him a small head for pressure and apparently his customers were satisfied. Later he purchased some lots where the Tucson Water Utility Plant No. 1 is located and installed a steam pump to give more pressure.

As Tucson grew, the 10-inch pipe became inadequate and Mr. Watts had a line of wells dug across the bottom land to the west. Later he had a single large well dug under the supervision of Mr. John Gardner. In 1898 Watts and his recent partner, Mr. H. A. Lawton, installed a stand pipe 70 feet in height and 30 feet in diameter at Fourth Avenue and Eighteenth Street, giving Tucson its first standby reserve.

In the same year, 1898, negotiations were begun to have the City purchase the private company. These were completed in 1900 and the City assumed control on July 24. The price was $110,000 covered by 50-year bonds. There were 625 customers and an annual revenue of $18,000.

The city did not expand the system until 1908 when the area between the railroad and the University began to develop. Prior to that time, each ranch or house north of the railroad had its own dug well and windmill.

The original City Water Farm consisted of 620 acres in the west half of Sections 2 and 11, Township 15 South, Range 13 East, in which the Watts' heading in the Santa Cruz River was located. Between 1908 and 1921 the development of additional water supplies was confined to this area and nearby land acquired by the City. Up to the present date 21 wells have been drilled for the Southside System, of which only 17 are now in service.

The next major expansion was the

creation of the northside system, by drilling three wells east of the University in 1921. Since that time the growth has been at a constantly accelerating rate, usually by the purchase of private water companies formed to serve new subdivisions. In other instances, the City Water Utility has been asked to come into areas.

The city is also developing its own supplies east of Davis-Monthan Air Base and south of the Municipal Airport. It also has permits to drill in other areas. The present capacity is estimated to be enough for 200,000 people.

There has been a considerable lowering of the water table within the inner basin with the center of lowering being located approximately under the University Campus. The accumulative effects of pumping within the city and metropolitan area are best illustrated by the long-period record of water levels in the University Well which is shown in Figure 10. It will be noted that no residual lowering occurred prior to the drilling of the three wells east of the Campus by the city in 1921. Slight lowering of the water table accompanied this development, but it was only with the increased pumping draft from wells to the east and southeast since 1936 that there has been significant and even accelerated rate of lowering of the water table. Recent development for additional water supplies east and north of Davis-Monthan Air Base has resulted in a shifting of the center of lowering to southeast of the University Campus.

For comparison water level records are shown in Figure 4, for the University Farm Well located on North Campbell Avenue close to Rillito Creek and a well located six miles east of the Campus well. The later reflects the gradual lowering of the water table in a well located outside the areas where the pumping draft takes place.

There are now, March 1957, 119 wells serving more than 140,000 people through more than 650 miles of pipe. These figures will be obsolete before this appears in print. The system is divided into several operating units, all to be interconnected for emergencies.

Naturally, the quality of the water varies rather widely, but by blending the sources, no undesirable water is used. Most of that pumped east of First Avenue from the 91 "mesa" wells is classed as moderately soft and has a low salt content. That from the 29 valley wells along the Santa Cruz River and in the north end of the Sahuarita Area is moderately hard and slightly salty. None of this water has enough fluorine to mottle teeth, while all contains some to insure hardness of teeth. It would not be desirable to add fluorine. The water as pumped is clear, odorless and bacteriologically pure. A light chlorination is given to protect against any contamination in distribution.

A flow of very soft water has been discovered at a depth of more than 500 feet under the city. While there is not enough to supply the city, some laundries have developed it for their own needs.

There are about 25 major water companies serving housing developments outside the city limits. There are also as many or more small companies and cooperative groups for the accommodation of neighbors. Practically all of both classes have their wells in the area being supplied. The exception to this is Catalina Foothill area which must pipe their water in from the Rillito-Tanque Verde bottom lands or the Cañada del Oro drainage. The quality, of course, depends on the source.

The Municipal Airport, Davis-Monthan Air Base, the hospitals and the larger industries have developed their own supplies, usually at the site of use. Often these are connected to the City system for standby protection. As the area has grown, many homes and former ranches have continued to use the wells they had when they were isolated. This proves feasible until a fall in the water table leaves them dry, or a major breakdown occurs making it cheaper to buy water and let others worry about repairs and deepening wells. It is not possible to estimate the number of these private wells, but it certainly runs into hundreds.

Practically all of this water is pumped from the "inner basin". Exceptions are the Municipal Airport and City wells to the south.

Vail Area

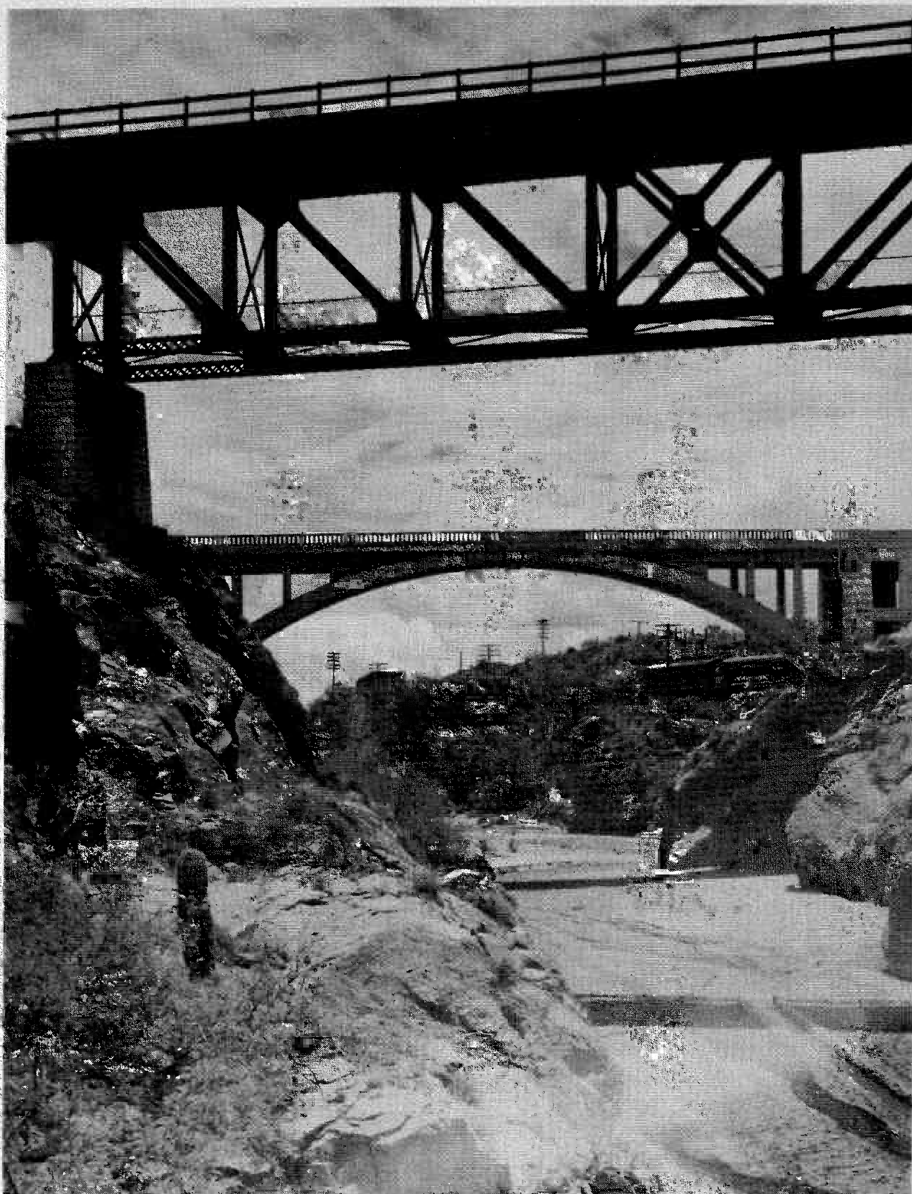
Southeast of Davis-Monthan Air Base is a large area of desert, undeveloped except for cattle ranches. This area lies outside the Inner Basin and west of the upper ground-water cascade. Wells in this area are few and far between, but the water table seems very consistent. The Southern Pacific drilled at Esmond to a depth of 1460 feet. Most of the lower half of this well is in clay formation. It is certain this was Pantano clay. The well two miles south of Vail was drilled through limestone, where a small flow water was encountered at a depth of 580 feet. The El Paso Natural Gas Company plant two miles south of Rita has two 500-foot wells. They are excellent producers. A correlation of the Quality of Water Map, Plate VI, with the Ground-Water Contour Map, Plate I, shows a flow of hard and slightly salty water entering the valley two miles southeast of Vail and flowing northwest about under Benson Highway to the vicinity of Craycroft or Alvernon Roads, where it turns north to cascade into the inner basin. The flow is premumably the underflow from Cienega Creek.

For comparison the analysis of the water from the Rita Station well is also given. This well is two miles north of the El Paso Natural Gas Company well. Four analyses are given in Table 9 to show this correlation with its source in Cienega Creek.

Table 9. – TRACING FLOW OF STREAM BY CHEMICAL ANALYSIS

Tracer Salts	Surface flow in Cienega Creek	Well 2 Miles South Vail	El Paso Natural Gas Company Wells	SP RR at Rita
Total soluble salts	876 ppm	824 ppm	870 ppm	302 ppm
Sodium	107	107	110	15
Chlorides	36	36	32	16
Sulphates	300	268	372	30
Hardness grain/gallon	18.4 gpg	18.5 gpg	20.3 gpg	9.8 gpg

ppm – parts per million
gpg – grains per gallon



PHOTOGRAPH 15

Narrows in Cienega Creek east of Vail. The very narrow, shallow stream bed forces the stream to flow on the surface here. Floods have been as high as the rock ledge in the foreground. Upper bridge is Westbound Southern Pacific Railroad, concrete arch is former highway bridge and top of eastbound S.P.R.R. bridge can be seen under left side of arch ahead of the train. There is a permanent flow here, which has been traced by chemical analysis for several miles.

SAHUARITA DISTRICT

The district lies south of San Xavier Mission and north of Santa Cruz county line. The bottom land is at its widest and the bluffs on the sides are either low or obliterated. It extends from the Sierrita Mountains to the Santa Ritas.

Sahuarita Area

This area occupies the bottom land of the Santa Cruz River from Sahuarita Butte to the north end of the Canoa land grant (Continental). It has excellent soil, good topography for irrigation and a fairly shallow water table.

The best land was first developed by the Tucson Farms Company in 1913-14. There was a little farming prior to that time. The Company drilled 24 wells — one of which was 900 feet deep — and had artesian pressure, but little flow. No attempt was made to use the artesian flow. After perforating all the casing the water stood within five feet of the ground surface. The artesian flow drains into the normal water table. The other wells were 200 to 500 feet deep. It has been necessary to replace many of the older wells, as the casings rusted out. There was also a small perched table under portions of this land, but it has disappeared.

The ground-water arteries are narrow, extending from south to north. Thus, at the headquarters of the Bombing Range a domestic well fluctuates with an irrigation well one-quarter mile to the south. Yet, it is almost unaffected by another irrigation well only 200 feet away to the west.

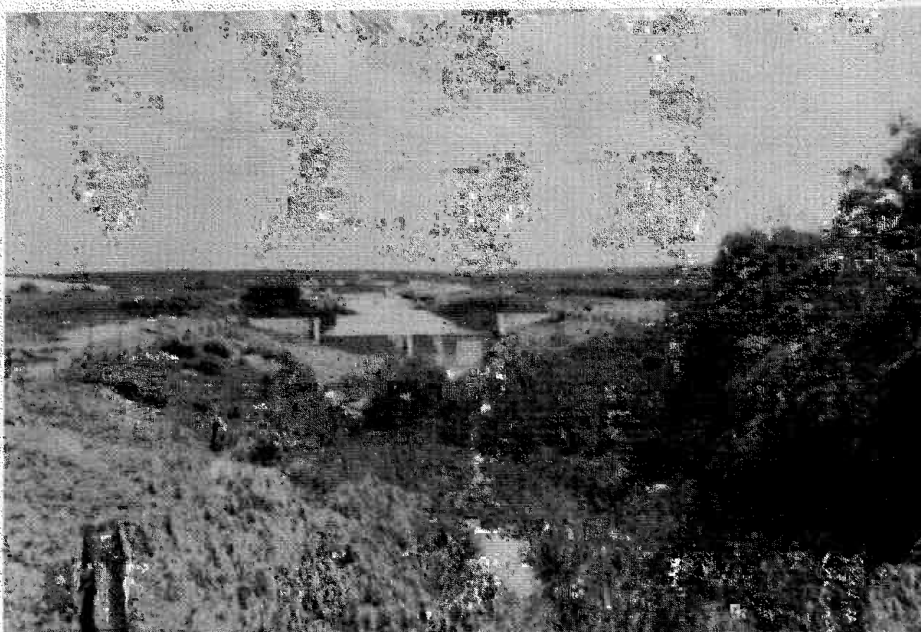
The profile, Figure 5, shows the loss from the original ground-water table. It may be noted that the exceptional runoff in the summers of 1954 and 1955 did not cause as much recovery in this area as elsewhere along the river course. There are two reasons for this. First, the area is much wider so that the inflow by seepage from the river channel would have to have been greater than elsewhere per mile of channel to have filled the greater area a comparable amount. Second, the farms in this area operate on a double crop system, so that there is more winter irrigation, precluding the wells from making their normal recovery before a measurement is taken.

The quality of the water is varied as might be expected. Most of the irrigation wells have a hard water, beneficial for irrigation, and moderate total salts. The deeper waters and those on the sides are of better quality than those in the center. Many of the samples show some nitrate content. This cannot be attributed to pollution, but is from natural sources, a common occurrence in desert areas. This is, of course, valuable as a fertilizer.

Sierrita Foothill Area

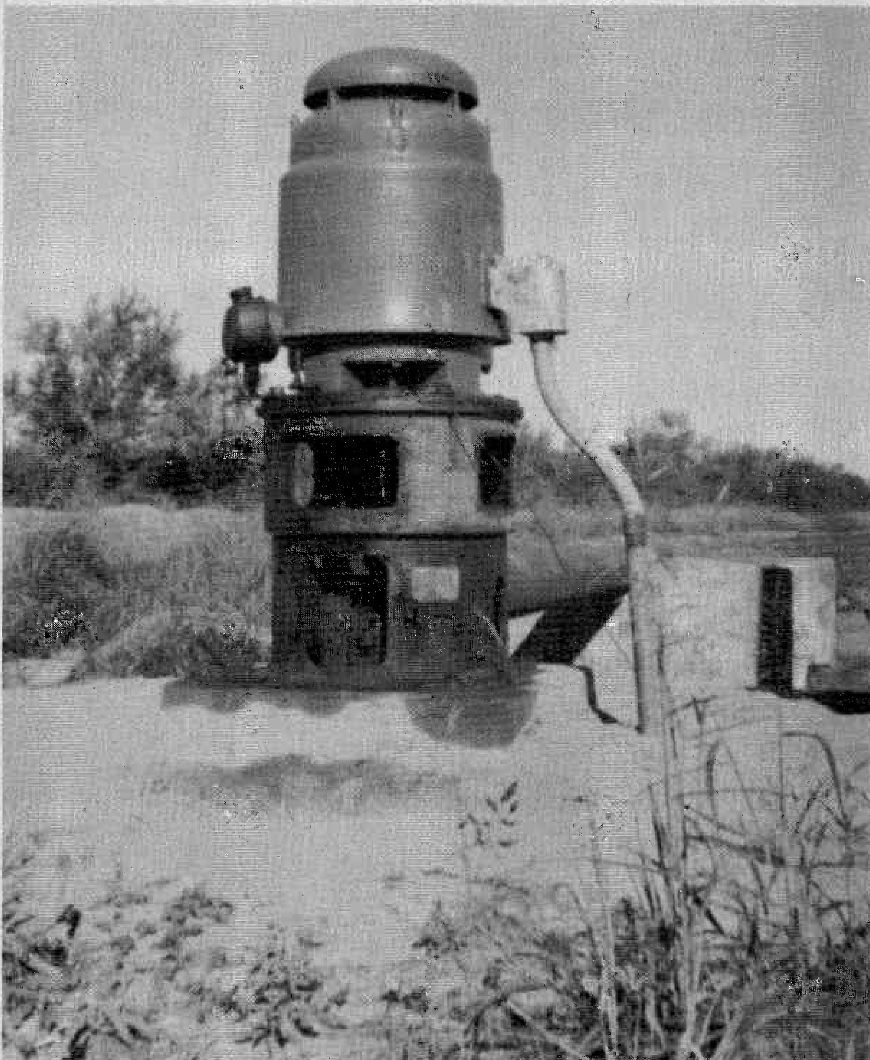
The Sierrita Bajada lies west of Santa Cruz River bottom land extending to the foot of the Sierrita Mountains. In the early days the exposed pediments were found to be mineralized and a large mine was developed at Twin Buttes. A railroad, since removed, was built. Later the San Xavier Mine was developed, the ore being trucked to a concentrator at Sahuarita. Recently, with the development of geophysical prospecting, several other ore bodies have been discovered.

One of these recent discoveries, the Pima Mine, is in operation after stripping 200 feet of alluvial overburden from the mineralized bedrock. The mill or concentrator is located at the pit and the water for operating it is pumped from the Santa Cruz River bottom land about six miles away to the east. Two other companies have prospected for and each developed a water supply near the east edge of the buried rock pediment. The water along the west edge of the valley is warm, about 90°F. This abnormal tem-



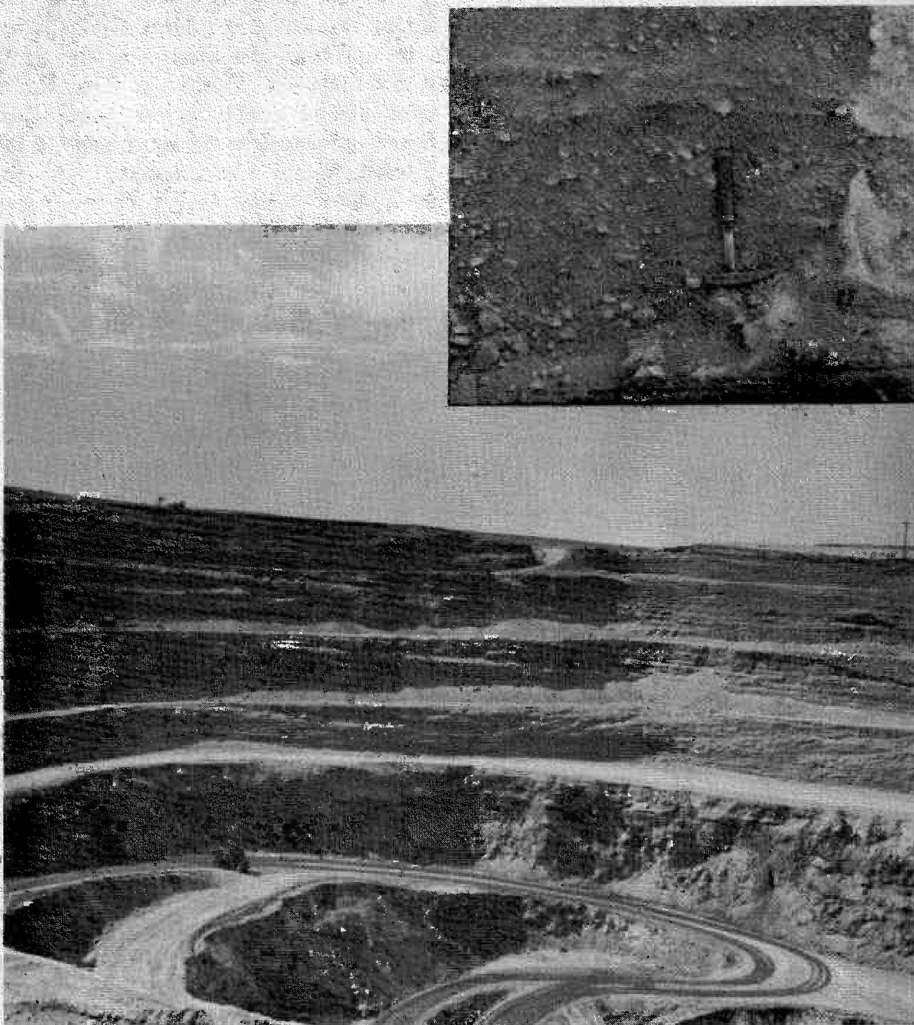
PHOTOGRAPH 16

Tail water, waste from lower end of fields near Sahuarita. This water, except for loss to ditch vegetation, represents return flow to ground water and may be considered as recharge or should be deducted from pumpage.



PHOTOGRAPH 17

Irrigation well at Sahuarita, Arizona. Trees mark bank of Santa Cruz River.



PHOTOGRAPH 18

Open pit of Pima Mine as an example of a buried rock pediment. There is 200 feet of alluvium, (see inset photo), overlying 20 feet of conglomerate, presumably pliocene formation on top of mineralized bedrock. This pit, large as it is, did not encounter any water though some water was found in the bedrock below the conglomerate, in a shaft mine at the same site. Photo by John Burnham.

perature is possibly the result of oxidation of sulphide minerals.

It is understood that the depth of the buried rock pediment is uniformly about 200 feet. Presumably the east edge of the pediment is marked by the line of small hills curving slightly east from Twin Buttes to south of San Xavier Mission. Many efforts to find water on top of the buried pediment have failed. In another instance, a well drilled in limestone went dry and was restored by deepening.

There are likewise a few small capacity wells on the pediment. One such well was much improved after creating an aquifer by damming a wash and allowing the stored water to filter through the sand. East of the rock pediment, the water table fluctuates with that of the river. The northwest trend of the contours indicates some recharge from the west. (See Plate I)

Bombing Range Area

In the desert area under the Bombing Range and to the east there are few wells. There is a trough indicated by the ground-water contours with a flatter than normal slope. Probably this is an old river channel. The wells in this area are deep, as much as 900 feet with a 700-foot water level. The quality of the water is excellent in most of them. However, those wells near the Santa Rita Mountains may have encountered the Pantano formation at 500-foot depth and have a capacity limited to stock or domestic use.

The City of Tucson is developing wells to the east of the Sahuarita bottom land, especially at the north end of the area. The ground-water contours (See Plate I) indicate this development should have little or no immediate effect on the irrigation supply for the farms along the river bottom. The quality from these wells, while usable, is harder than desired, but their capacity is the best yet developed. The location of the City wells is indicated on the maps. (See Plates I, III, and VI)

Continental-Canoa Area

This lies from the south side of the Sahuarita area to the Santa Cruz County line and from the Sierrita to the Santa Rita Mountains. The Santa Rita Mountains extend nearly to the Santa Cruz River and complete the south edge of the Tucson Basin. Unfortunately, for our study, there are no wells back more than two miles from the edge of the bottom land on either side of the river in this section. An attempt to develop water was made 6 miles east of Continental, but was abandoned after drilling 500 feet. No rock or other impervious material was encountered and an extension of the ground-water contours indicated water might be as deep as 650 feet.

The San Ignacio de la Canoa land grant to Tomas and Ignacio Ortez was issued by the State of Sonora in 1821. It was sold in 1880 to Frederick Maish and Thomas Driscoll for 120 dollars, or about seven-tenths of a cent per acre. There was a surface water right with the original grant, so it may be presumed the river was flowing most of the time in the early nineteenth century.

Since the Canoa Grant was established under Mexican sovereignty the rectangular system of land surveys used in the United States cannot be applied. However, for the purposes of this bulletin the sections have been projected into this area.

In July 1916 the Continental Rubber Company purchased the north half of the Canoa Grant for the production of guayule for rubber. By 1920 approximately 1100 acres of this shrub were under irrigation, but the drastic drop in mid-1920 in the price of rubber made production unprofitable and until 1951 most of the acreage was out of cultivation. Since

PHOTOGRAPH 19

View of Canoa Ranch of Upper Santa Cruz Valley. Cayente Hills on left and Tumacacori Mountains on right. The bajada from the Santa Rita Mountains appears at the left. Photo by Walker Bryan.

then, the irrigated acreage has been increased to 3400 and with heavier pumping, there has been noticeable lowering of the water table.

There was little agriculture on the south half of the Canoa Grant until about 1951 when the larger sections of the bottom land were cleared and several wells were drilled. South of the Canoa Grant there has been some farming for many years.

At the Kinsley Ranch on the County line an experiment in recharging ground water has been under way for some years. Mr. Kinsley has a lake which he maintains for recreation, by pumping. He also diverts flood waters from a small watershed into this lake and when there is a surplus in the lake, he returns it to the ground-water table through an irrigation well. Since this well is often pumped, the sediment remaining in the lake water is flushed from the soil around the well and so far, after several years, the capacity of the well to receive or yield water is unimpaired.

The flood flows in the Santa Cruz during the summer of 1954, which have been referred to previously, were effective in providing recharge to the Sahuarita District. This was the first year in the 13 years of water level measurements, previous to the spring of 1955, in which a significant recovery of the water table has taken place and this was repeated in the summer of 1955. The spring water level measurements of 1956 reflected a similar, though smaller, recovery. As compared with the spring of the previous year, the profile of the water table for 1956 indicates recovery of between two feet and five feet.

The ground-water lowering is shown in Plate II for the Sahuarita-Continental areas for the period 1947-1956. Since there are but few wells located at any distance from the center of the valley, the exact limits of the outer fringe of the area of lowering are not known. In general, as is expected, the maximum residual lowering or volumetric loss occurred in the areas of heaviest pumping, but unwatering of the ground-water reservoir underlying the adjacent mesa land has also taken place.

SANTA CRUZ COUNTY

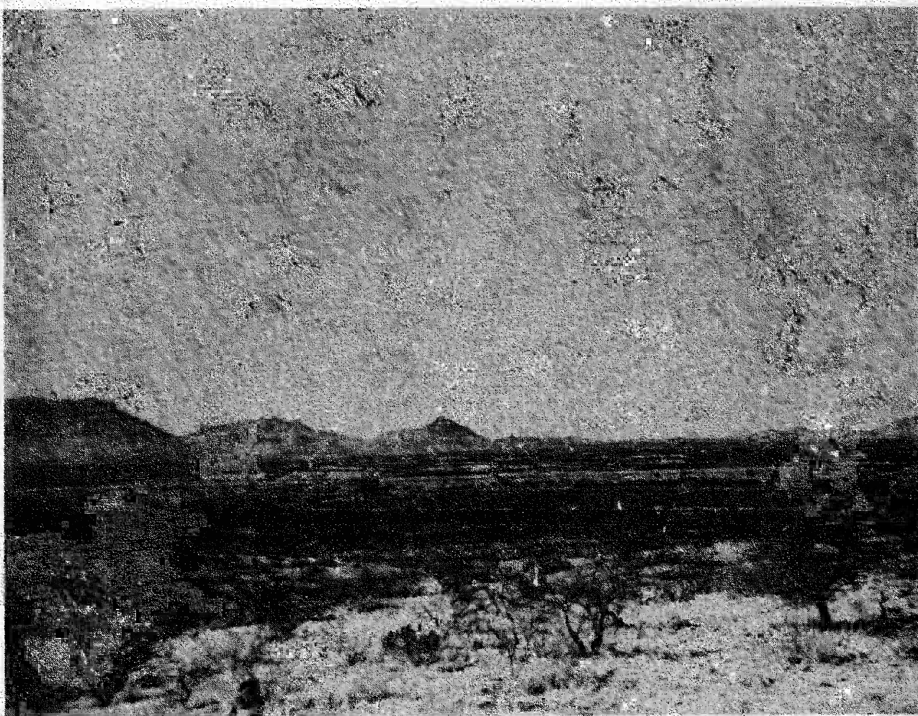
Amado-Tubac Area

This area includes that portion of the Santa Cruz Valley from the Pima-Santa Cruz County line south to the junction of Nogales Wash with the Santa Cruz River just above (south of) the site of Calabasas. Since there are but few wells and little information concerning the groundwater conditions underlying the mesa formations, it deals for the most part with the bottom land areas along the river.

A reconnaissance of the side slopes found indications that the older alluviums extend to within a mile or two of the river bottoms. If this proves correct, a situation similar to that described in the section, Catalina Foothills-Tanque Verde Area, will be found. A large part of the south half of the area was originally a part of the Baca Float, an old Spanish land grant, and the old settlements of Tubac and Calabasas were made prior to 1700 becoming the seats of the earliest agricultural developments in Southern Arizona.

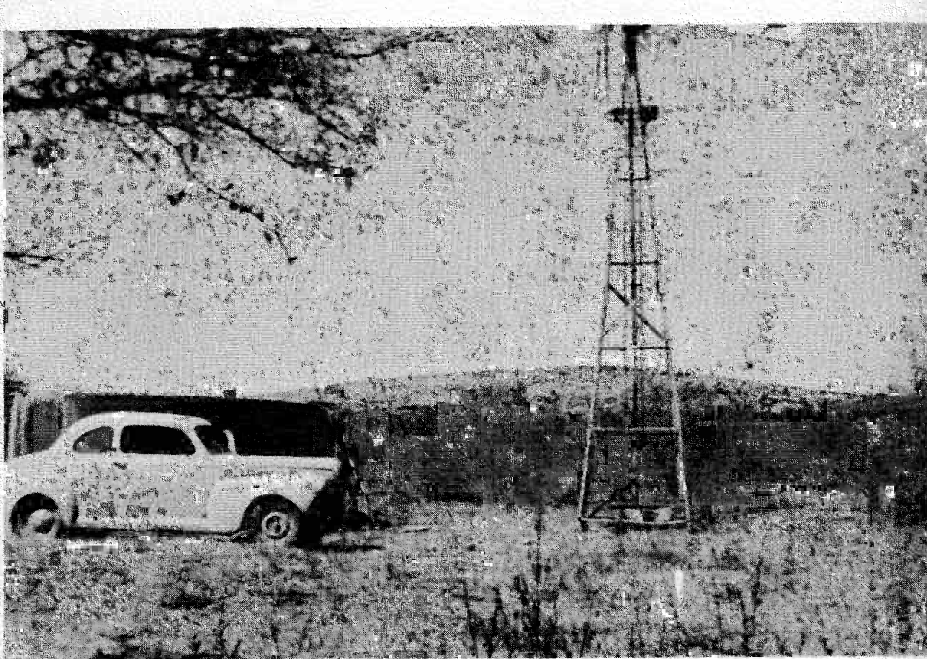
Irrigation from wells was practiced to a very limited extent prior to 1920, but pumping in appreciable amounts did not commence until after 1935. Complete records of water levels in the area are not available until the spring of 1940 and information from earlier records indicates that even in the areas of most pumping, there had been lowering of not more than 5 or 6 feet.

Throughout this area the water table reached its lowest point in history in the spring of 1954 and at this time static



Photograph 20

Looking north, down Santa Cruz Valley, from top of bluff at end of Santa Rita Bajada near Amado, Arizona.



PHOTOGRAPH 21

Sonoita Creek Windmill. Well in Older Conglomerates about 2 miles east of Santa Cruz River in Sonoita Creek bottom land. Here the aquifer is very thin and this well is in Pantano formation, or a similar Older Conglomerate. Its capacity is about that of the windmill pump.

PHOTOGRAPH 22

Heavy growth of unusable grass in Sonoita Creek bottomland. This represents a waste of water. This type of growth occurs in flood plain or where water table is very shallow. Its demand for water exceeds that of most crops, i.e., there would have been less water used, had this field been in grain sorghum or cotton.

water levels varied from less than 20 feet to about 60 feet in the trough of the valley. Maximum residual loss was observed in the vicinity of Calabasas as was also the greatest recovery amounting to as much as 43 feet from the exceptional floods in the summers of 1954-1955. The profiles of the water table in the trough of the valley as shown by spring water level measurements in 1940, 1947, 1954, 1955 and 1956 are given in Figure 6. This serves to emphasize how important are these periods of above normal rainfall and runoff in maintaining or replenishing a shallow ground-water reservoir of the type found in this area.

The profile of this area (Figure 6) shows that the water levels were the highest in history in the summer of 1956. In fact, at mile 70, on the profile, the water table equalled the ground surface in an old cienega east of the railroad track, and caused some crop damage. The levels have receded considerably because of the meager runoff of 1956.

The river bed in the vicinity of Calabasas is ideal for recharge, being very wide and composed of coarse sand. North of Otero siding, the bed of the river is in clay and a much narrower channel, which is reflected in the smaller amount of recharge.

The Recent valley fill forming the bottom land constitutes the principal aquifer. It varies in depth from 80 to 100 feet and most of the irrigation wells penetrate the underlying older valley fill for only a short distance. The largest capacity well in the Santa Cruz Valley above Rillito is located in Section 35, T. 22 S., R. 13 E., near old Calabasas and it has a capacity of over 5000 gallons per minute.

The ground-water contours indicate, in general, a fairly uniform slope down the valley of approximately 20.7 feet per mile with a constriction in the cross-sectional area of the Recent fill noticeable by the steepening of the ground-water slope in the stretch at Tubac. In general, the wider spacing of ground-water contours is fairly indicative of the more favorable well locations. The residual lowering in water levels for the period of record, 1940-1954, for the inner valley is shown in Plate IV.

An unexplained anomaly is presented by the ground-water trough paralleling the Santa Cruz River about three miles west of the mouth of Sopori Wash. (See Ground-Water Contour Map, Plate III) The ground-water contours indicate underflow from the present valley trough is into this presumably older channel or fault in the valley fill which is located close to the rock slopes on the west. Information is not available to determine the direction of movement of this ground-water, nor where it again joins the central trough of the underflow of the valley. Possibly this ground-water depression is caused by too much pumping and poor recharge from either the Santa Cruz River or Sopori Wash. On the west side of this ground-water valley is the edge of the rock pediment. This intercepts or diverts the ground-water movement down the Sopori Wash. An infiltration gallery or horizontal well on top of the rock drains much of this underflow, which is used for irrigation on the bottom land of the wash west of the Nogales Highway.

Nogales Wash and Quebabi Areas

The Santa Cruz River above its junction with Sonoita Creek flows over some granite outcroppings and through narrows which have been considered as reservoir sites for the regulation of flood flows and recreation areas. The stream channel and bottom lands are very narrow with limited opportunities for agriculture, some of which have been utilized. In many places the aquifer is so constricted as to force nearly the entire ground-water flow to the surface. Near the bridge for the Nogales-Patagonia Road, a small ground-water reservoir occurs which is utilized for the water supply for the City of Nogales. The city supply has been developed by sinking a shaft alongside the river channel in solid rock tunneling into the rock under the river and boring holes from the top of the tunnel into the alluvium of the stream channel. In this way every drop of percolating water can be withdrawn from the river bed. The water level in this tunnel stands at the level in the stream bed and is subject to fluctuations of about 45 feet depending on the underflow or surface flow. The water is of excellent quality and does not contain the high salt content characteristic of percolating waters of the Santa Cruz farther down. The first two miles north of the International Boundary line, the stream channel and bottom land are very narrow and underlain with cemented material at a depth of 40 feet.

Nogales Wash, which leaves the Santa Cruz River about a mile above Sonoita Creek, has a few irrigated areas, more of the suburban home type and a small acreage of irrigated pasture. While the drainage area is small and probably would not support even this development, there is a constant and ample recharge from the effluent of the Nogales City sewage disposal plant. Filtration through the soil removes all danger of pollution.

Mexico

From Lochiel where the Santa Cruz River leaves the United States to the point where it returns to the United States, a distance of 35 miles, the flow is increased from two to as much as twelve times for the years of record 1949 to 1952. This represents the surface contribution of Mexico over and above its withdrawals of all types, both natural and artificial. Reports state there are approximately 2000 acres under irrigation in use. No work has been done in the portion of the drainage area above the International Boundary.

APPENDIX I

METHODS OF MEASURING WELLS

Steel Tape

There are three practical methods of measuring water levels in common use. First, the surveyors steel tape, which is the method used by the Agricultural Engineering Department for most measurements. An ordinary surveyors tape 1/4 by 1/50 inch and long enough to reach the water level is ordinarily used. The end of the tape is colored with blue carpenter's chalk to show the water level mark clearly. The tape is then lowered into the well to a depth estimated to be the water level. If the tape does not reach water, a greater depth is tried. If all the chalked tape is wet, a lesser depth is tried. This process is repeated until a water mark is obtained on the last foot of tape. Usually a tape with a calibrated foot below the zero mark is used and the decimal is thus read directly. In wells without a pump or with ample clearance between the column pipe and casing, a quarter to half a pound of lead in a long slender stick is used to guide the tape down. In wells with small clearances or small openings at the top, a tape, from which the brass ring has been removed, is used in order that there be no point with a greater dimension to catch behind a coupling or in a tear in the casing. If it is necessary to use a tape without a weight, two measurements are made. In one measurement several feet of tape is wetted and the wetted portion subtracted from the amount of tape in the well. This must check the end-foot measurement to insure that the end of the tape has not been held by a rough spot, so that the tape curls up in the well.

In wells into which water is leaking either from the pump head, a bad pipe joint, or an upper strata, such as a perched table, the tape method cannot be used, as the tape will be wetted far above the true water surface. Usually it is impossible to get a check between two successive measurements in such a well. Photograph 12 shows a steel tape being used to check the continuous recorder.

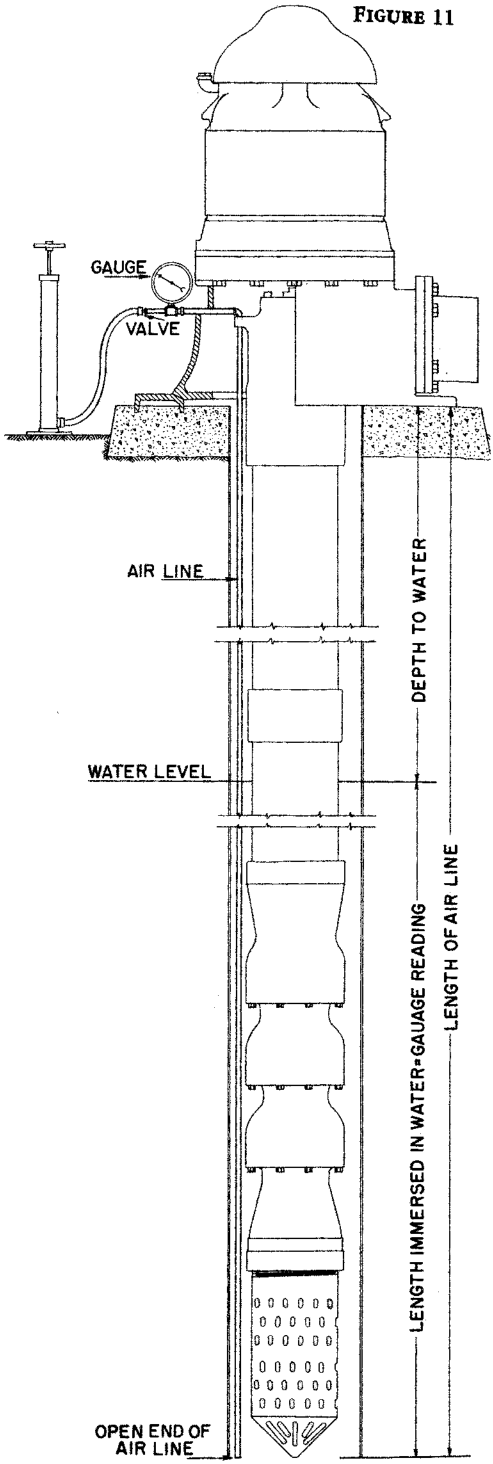
Air Lines

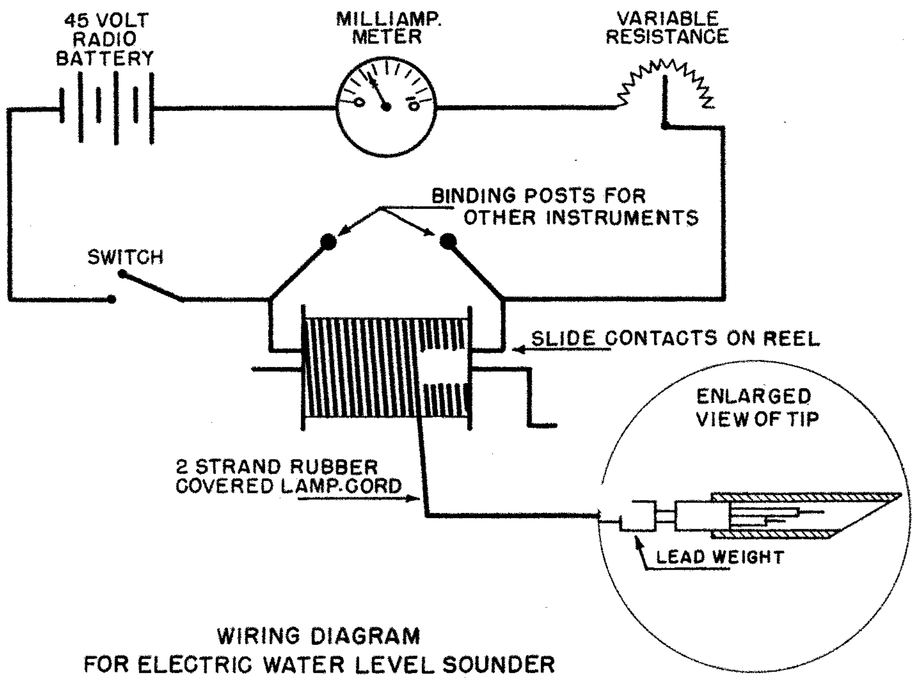
In wells with wet sides, or wells to be measured while pumping for a drawdown test, an air line is often installed. This consists of a small copper or iron pipe with the lower end open, lowered into the well to a greater depth than the pump. The upper end is fitted with a tee, air gage and air check valve. Usually the length of line below the customary measuring point is known, the tee, gage and air valve need not be at this elevation. A water level measurement is made by pumping air into the air line slowly until no higher reading on the gage can be obtained. The reading must be taken with little or no air moving in the pipe or the friction of the air will be added to the gage pressure. This pressure then represents the head of the water between the lower end of the air line and the true water surface. By converting the gage pressure into feet of water and substracting this figure from the length of the air line, the true water level is obtained. In the event the length of air line is unknown or questioned, it should be checked by obtaining a static water level measurement with either a steel tape or an electric sounder. A diagram of an air line is given in Figure 11.

Electric Sounders

Sometimes it becomes necessary to obtain a measurement on a wet well, wet above the true water surface, which is not equipped with an air line. In this case, an electric device may be used. A two-wire sounder equipped with a tip as shown in Figure 12 and powered by a 45-volt radio battery has proved quite satisfactory. However, if the quantity of water

FIGURE 11





WIRING DIAGRAM
FOR ELECTRIC WATER LEVEL SOUNDER

cascading into a well is too great, it may drown the electrodes and if the turbulence created by falling water is too full of air, steady readings cannot be obtained because of air bubbles passing through the tip. The practice has been adopted of testing the tip in a sample of the water, if available, before a sounding is to be made in order that the conductivity of the water and ammeter reading can be recognized when the tip reaches the water. Dampness in the well or falling water will cause violent fluctuations of the meter and are not to be confused with a steady reading at the true point of immersion. Considerable trouble is often encountered in trying to get the soft copper wire with its flexible and relatively large tip down a well, especially if the water is at great depths so that many feet of wire can be passed into the well without a change of pull being noticed as will be the case if a steel tape "hangs up". If the tip has reached enough water from dampness or other source to cause a partial or unsteady reading, a steady reading lower than expected from preliminary test, usually indicates that the tip has fouled and is lying still, and the wire is merely coiling up in the well.

Because no satisfactory method of marking the length on rubber-covered electrical wire has been devised, the wire is marked with chalk when a measurement has been determined, withdrawn from the well, laid out on the ground, and measured with a steel tape. Copper wire also acquires a permanent stretch if subjected to excessive strain from a deep measurement or in being pulled free from an obstruction in the well.

APPENDIX II

Logs of Representative Wells in Santa Cruz Valley

Location	Date Drilled	Depth	Material	Water Level When Drilled
Section 27F T12S, R12E	Feb. 1913	0- 12	Soil	103 feet
		12- 97	Gravel	
		97- 104	Gravelly clay, some water	
		104- 110	Fine sand and clay	
		110- 117	Boulders, some clay	
		117- 128	Gravel, some clay	
		128- 141	Clayey gravel	
		141- 209	Laminated cemented and loose gravel	
		209- 214	Boulders	
		214- 300	Gravel, cemented and loose	
Northwest corner Sec. 8D T12S, R12E	1947	0- 10	Sand	158 feet
		10- 60	Gravel and boulders	
		60- 165	Gravel and sand	
		165- 170	Clay	
		170- 240	Sand and gravel	
		240- 265	Sand and rock	
		265- 282	Sand very firm	
		282- 292	Sand rock very hard	
Sec. 5N T12S, R13E	Sept. 1955	0- 3	Soil	462 feet
		3- 112	Sand, gravel, boulders, some clay	
		112- 190	Sand, very little clay	
		190- 250	Loose sand and gravel	
		250- 290	Sand, gravel and clay	
		290- 310	Loose sand	
		310- 360	Clay, some sand, hard	
		360- 380	Loose gravel and boulders	
		380- 400	Cemented sand	
		400- 470	Sandy clay	
		470- 480	Loose sand, fine, struck water at 475 feet	
		480- 500	Loose sandy clay	
		500- 505	Loose fine sand	
		505- 570	Sandy clay	
Sec. 22D, T12S, R13E	June 1936	0- 60	Sandy soil (some clay)	205 feet
		60- 70	Gravel and small boulders (very loose)	
		70- 100	Sandy soil (some clay)	
		100- 115	Loose sand	
		115- 123	Sand clay and gravel	
		123- 160	Small boulders (some clay)	
		160- 200	Sand and clay	
		200- 205	Clay and gravel (water)	
		205- 210	Coarse gravel and boulders	
		210- 230	Clay and sand (some gravel)	
		230- 233	Clean sand and gravel (loose)	
		233- 268	Clay, sand and gravel	

Location	Date Drilled	Depth	Material	Water Level When Drilled
Sec. 36P T13S, R13E	April 1950	0- 1	Soil	103 feet
		1- 6	White caliche	
		6- 90	Red Clay and gravel	
		90- 110	Yellow clay, gravel and some boulders	
		110- 134	Red clay, gravel and some boulders	
		134- 145	Sand	
		145- 188	Red sandy clay	
		188- 245	Hard red clay and sand	
		245- 270	Red clay, sticky, very little fine sand	
		270- 290	Red clay, very hard, little sand	
		290- 314	Red clay, sticky, little sand	
		314- 332	Red clay, hard, little sand	
		332- 345	Red clay, very sticky. some sand	
		345- 360	Red clay, very sticky some dark sand	
		360- 375	Brown sticky clay, some sand (dark)	
Sec. 7F T14S, R14E	Dec. 1912	0- 75	Alternate strata of cemented gravels and adobe	75 feet
		75- 95	Gravel (water bearing)	
		95- 100	Caliche	
		100- 113	Clay	
		113- 185	Gravel (water bearing, partly cemented)	
		185- 190	Cemented sand	
		190- 205	Gravel (water bearing)	
		205- 230	Dry sand	
		230- 300	Gravel (water bearing)	
		300- 350	Fine brown sand	
		350- 370	Gravel (warm water)	
		370- 385	Red clay	
		385- 460	Sand	
		460- 465	Red clay	
		465- 493	Sand and gravel	
		493- 504	Sand (water bearing)	
		504- 513	Hard sand and gravel	
		513- 541	Sand and gravel (water bearing)	
		541- 550	Granite gravel	
		550- 565	Dry sand	
Sec. 25B T14S, R15E	Feb. 1953	0- 3	Rocky red conglomerate	380 feet
		3- 5	Dry sand	
		5- 100	Sandy brown conglomerate	
		100- 380	Sandy gray conglomerate	
		380- 390	Sandy brown conglomerate	
		390- 392	Sand and gravel—water	
		392- 410	Sandy brown conglomerate	
		410- 417	Coarse sand and gravel—water	
		417- 430	Sandy gray conglomerate	

Location	Date Drilled	Depth	Material	Water Level When Drilled
		430- 440	Sandy brown conglomerate	
		440- 460	Sandy gray conglomerate with water	
		460- 465	Hard shell	
		465- 480	Brown sand	
		480- 493	Brown clay conglomerate	
Sec. 3L T15S, R14E	1956	0- 95	Buff colored clay with layers of sand	147 feet
		95- 115	Mostly clay, few fine sand layers	
		115- 135	Layers of clay, sand and gravel, rounded quartz grains	
		135- 155	Clay with some sand layers	
		155- 205	Mostly clay with few thin layers of sand	
		205- 245	Clay with layers of sand	
		245- 265	Mostly clay with few thin layers of sand	
		265- 285	Layers of sand, gravel, and clay	
		285- 295	Mostly clay with layers of fine sand	
		295- 345	Sand, gravel and clay in layers	
		345- 355	Mostly clay with thin layers of fine sand	
		355- 365	Clay and thin layers of fine sand	
		365- 405	Sand, gravel and clay in layers	
		405- 415	Clay and thin layers of fine sand	
		415- 435	Clay and sand in layers	
		435- 445	Sand, gravel and clay in layers	
		445- 455	Clay and very fine sand in layers	
		455- 465	Clay and sand in layers	
		465- 475	Sand, clay and small gravel in layers	
		475- 495	Clay and fine sand in layers	
		495- 505	Clay and sand in layers	
		505- 525	Clay and fine sand, very sticky	
		525- 565	Same but more sand	
		565- 575	Clay and sand in layers	
		575- 595	Clay and fine sand	
		595- 605	Same but more sand	
		605- 615	Very sticky clay with few thin sands	
		615- 645	Very little fine sand—95% clay	
		645- 675	Same—slightly more fine sand	
		675- 695	Grey, fine, quartz sand — 30-50% clay	
		695- 705	Same—70-80% clay	
		705- 715	Little grey, fine quartz sand—90-95% clay	
		715- 745	Rounded. fine grained, buff colored volcanic fragments—30% clay	

Location	Date Drilled	Depth	Material	Water Level When Drilled
		745- 755	Same but smaller grain size—60% clay	
		755- 765	Very fine quartz sand — 20% clay	
		765- 785	Mostly clay, some fine sand, 90% clay	
		785- 795	Same—95% clay	
		795- 845	Same—slightly more very fine sand	
		845- 865	Same — slightly less very fine sand	
		865- 875	Same—95% clay	
		875- 915	Same— slightly more very fine sand	
		915- 925	Same — slightly less very fine sand	
		925- 935	Same—more fine sand and some 1/4" pebbles	
		935- 945	Mostly clay—little very fine sand	
		945- 955	Mostly clay—less very fine sand	
		955- 995	Same—note fine mica flakes	
		995-1035	Same—sand very slightly coarser	
		1035-1075	Same—one or two 1/4" fragments of granitic rock	
		1075-1085	Same with fine grained white caliche	
		1085-1095	Same with some fine grained white caliche	
		1095-1115	Same—more caliche than sand	
		1115-1150	Log unavailable	
Sec. 4I T16S, R15E	1952	0- 20	Boulders, gravel	375 feet
		20- 40	Gravel	
		40- 45	Sand	
		45- 70	Gravel	
		70- 180	Gravel	
		180- 235	Gravel	
		235- 375	Streaks of clay	
		375- 455	Sand, gravel, water	
		455- 495	Sand, gravel, clay, water	
		495- 505	Sand, gravel, clay, water	
Sec. 7P T17S, R14E	1914	0- 3	Soil-silt and sand	5 feet
		3- 16	Gravel and loose boulders	
		16- 43	Gravel and hard boulders	
		43- 55	Dark clay and gravel	
		55- 63	Light streak, clay and gravel	
		63- 84	Soft clay	
		84- 92	Tough clay	
		92- 100	Sand streaks with clay mixed	
		100- 148	Clay with hard streaks	
		148- 153	Sand and gravel, water bearing, loose	

Location	Date Drilled	Depth	Material	Water Level When Drilled
		153- 198	Hard brown clay, soft streaks (took water)	
		198- 203	Sand and gravel	
		203- 227	Clay and gravel, hard	
		227- 228	Hard boulder	
		228- 232	Sand and gravel	
		232- 235	Tough clay	
		235- 240	Sand and gravel	
		240- 248	Clay and sand streaks	
		248- 273	Tough clay with hard streaks	
		273- 290	Sand and gravel, loose	
		290- 300	Tough clay with soft streaks	
		300- 306	Soft clay and gravel	
		306- 343	Tough clay, light	
		343- 350	Soft clay and gravel	
		350- 367	Tough light clay	
		367- 370	Soft clay	
		370- 394	Tough clay	
		394- 397	Boulders and hard clay	
		397- 413	Gravel, sand, boulders, cemented streaks	
		413- 421	Clay and gravel, hard	
		421- 426	Sand and gravel. not very loose	
		426- 436	Hard clay	
		436- 440	Sand and gravel	
		440- 448	Tough clay and gravel	
		448- 453	Soft clay and sand streaks	
		453- 456	Hard clay	
		456- 459	Very soft clay	
		459- 467	Very tough clay	
		467- 470	Hard gravel and sand, very hard and packed	
		470- 477	Soft clay, hard streaks	
		477- 479	Boulders	
		479- 509	Tough clay	
		509- 512	Clay with sand streaks	
		512- 515	Tough clay	
		515- 520	Sand and gravel	
		520- 535	Tough clay	
		535- 540	Very hard clay	
		540- 544	Clay and gravel, hard	
		544- 565	Hard brown clay	
		565- 571	Soft clay	
		571- 585	Tough clay	
		585- 590	Soft clay	
		590- 595	Tough clay	
		595- 608	Very hard clay	
		608- 641	Tough clay, soft streaks	
		641- 664	Hard brown clay, tight	
		664- 669	Soft clay-sand mixed	
		669- 723	Tough red clay	
		723- 741	Soft clay-brown sand streaks—water seepage	

Location	Date Drilled	Depth	Material	Water Level When Drilled
		741- 752	Hard brown clay	
		752- 773	Very tough clay	
		773- 779	Soft brown clay	
		779- 790	Hard clay	
		790- 798	Soft brown clay	
		798- 804	Hard clay shale	
		804- 812	Soft clay	
		812- 830	Hard brown clay shale	
		830- 872	Tough clay (gravel mixed)	
		872- 880	Soft brown clay	
		880- 903	Hard brown clay (soft streaks)	
		903	Rock-orders to quit	
Sec. 12.0	Jan.	0- 6	Sandy clay	48 feet
T18S, R13E	1952	6- 10	Sandy clay	
		10- 45	Clay, gravel	
		45- 105	Sandy clay	
		105- 120	Sticky clay	
		120- 130	Cemented sand	
		130- 140	Sticky clay	
		140- 160	Cemented sand	
		160- 300	Cemented sand with streaks of sticky clay	
Sec. 7N	Aug.	0- 25	Dug 96″ caisson	20 feet
T20S, R13E	1938	1- 24	Cemented pit	
		24- 32	Fine sand-gravel	
		32- 51	Coarse gravel	
		51- 64	Coarse gravel-red clay	
		64- 71	Red clay-sticky	
		71- 73	Coarse gravel-little clay	
		73- 81	Red clay-sticky	
		81- 94	Red clay-coarse gravel	
		94- 104	Packed sand, little clay	
		104- 115	Sandy clay, cavey	
		115- 117	Red clay—sticky	
		117- 129	Packed sand, little clay	
		129- 134	Red clay, sticky	
		134- 172	Packed sand, little clay	
		172- 175	Red clay, sticky	
		175- 180	Packed sand	
Sec. 31A	July	0- 1	Silt	19½ feet
T21S, R13E	1949	1- 30	Boulders and gravel	
		30- 75	Red clay, boulders, gravel	
		75- 100	Clay, boulders, silty	
		100- 137	Large boulders, clay	
		137- 142	Sand, gravel	
		142- 150	Large boulders, clay	
		150- 222	Cement, boulders and gravel	

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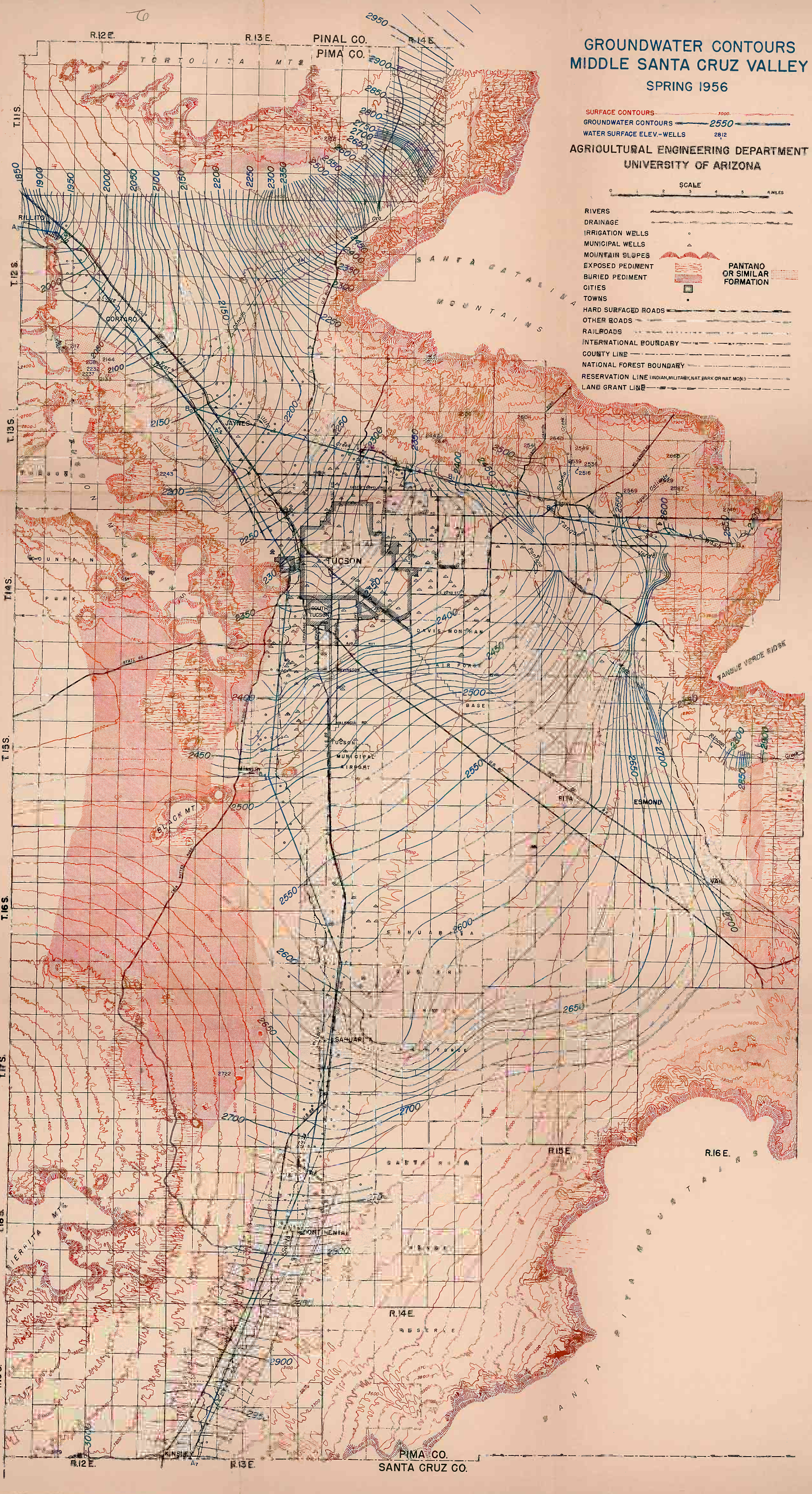
INDEX

K — Key Map facing page 1.
B — Base Maps, in pocket.

PLATE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AGRICULTURAL ENGINEERING DEPARTMENT
UNIVERSITY OF ARIZONA
SCALE
RIVERS
DRAINAGE
IRRIGATION WELLS
MUNICIPAL WELLS
MOUNTAIN SLOPES
EXPOSED PEDIMENT
BURIED PEDIMENT
PANTANO OR SIMILAR FORMATION
CITIES
TOWNS
HARD SURFACED ROADS
OTHER ROADS
RAILROADS
INTERNATIONAL BOUNDARY
COUNTY LINE
NATIONAL FOREST BOUNDARY
RESERVATION LINE (INDIAN, MILITARY, NAT. PARK OR NAT. MON.)
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PIMA CO.
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R.13 E.
R.14 E.
R.15 E.
R.16 E.
T.11 S.
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T.18 S.
T.19 S.
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SANTA CATALINA MOUNTAINS
TANQUE VERDE RIDGE
SANTA RITA MOUNTAINS
SIERRITA MTS.
BLACK MT.
TUCSON
SOUTH TUCSON
CORTARO
JAYNES
RILLITO
DAVIS MONTHAN AIR FORCE BASE
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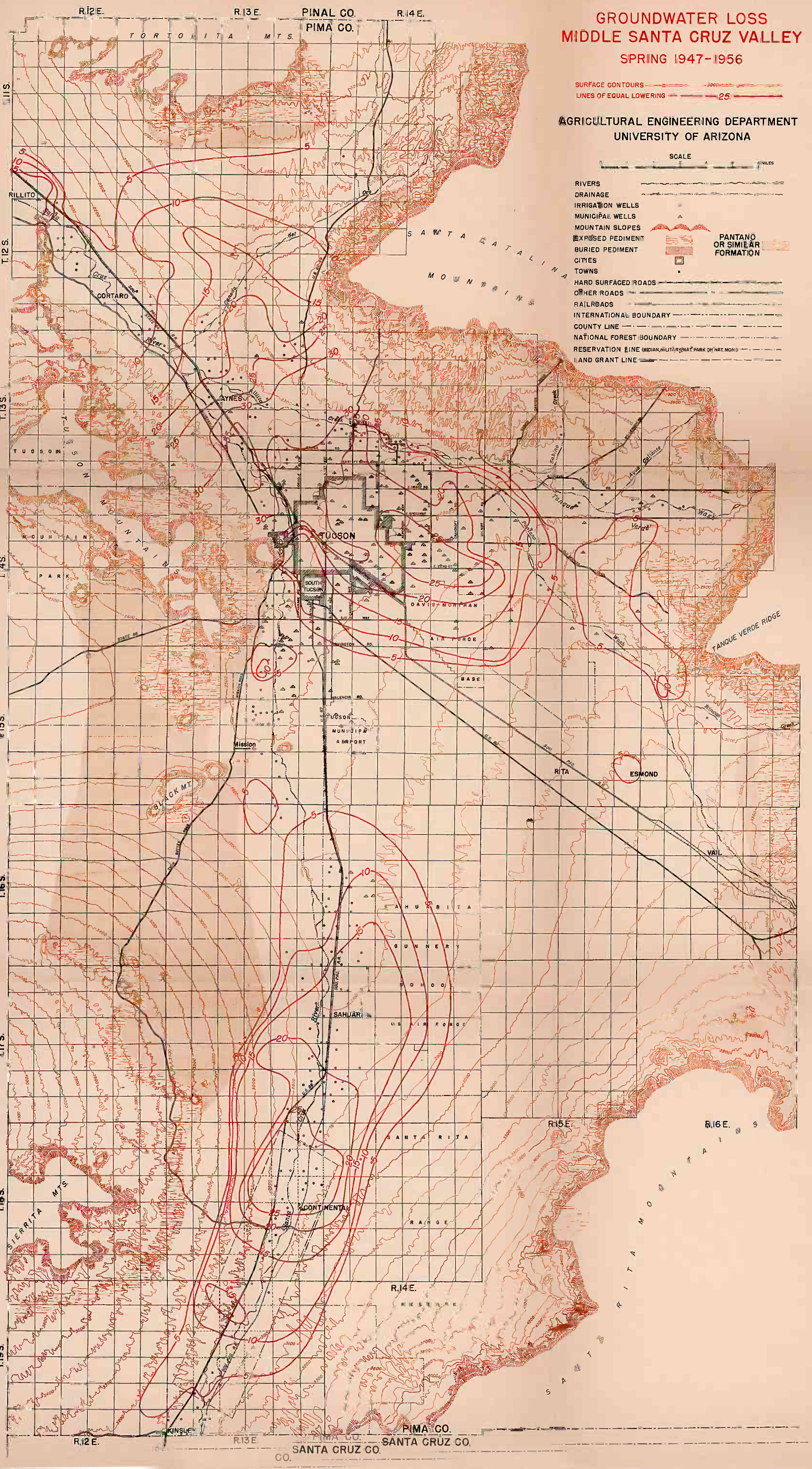
PLATE II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AGRICULTURAL ENGINEERING DEPARTMENT
UNIVERSITY OF ARIZONA
SCALE
RIVERS
DRAINAGE
IRRIGATION WELLS
MUNICIPAL WELLS
MOUNTAIN SLOPES
EXPOSED PEDIMENT
BURIED PEDIMENT
PANTANO OR SIMILAR FORMATION
CITIES
TOWNS
HARD SURFACED ROADS
OTHER ROADS
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DAVIS-MONTHAN AIR FORCE BASE
TUCSON MUNICIPAL AIRPORT
Mission
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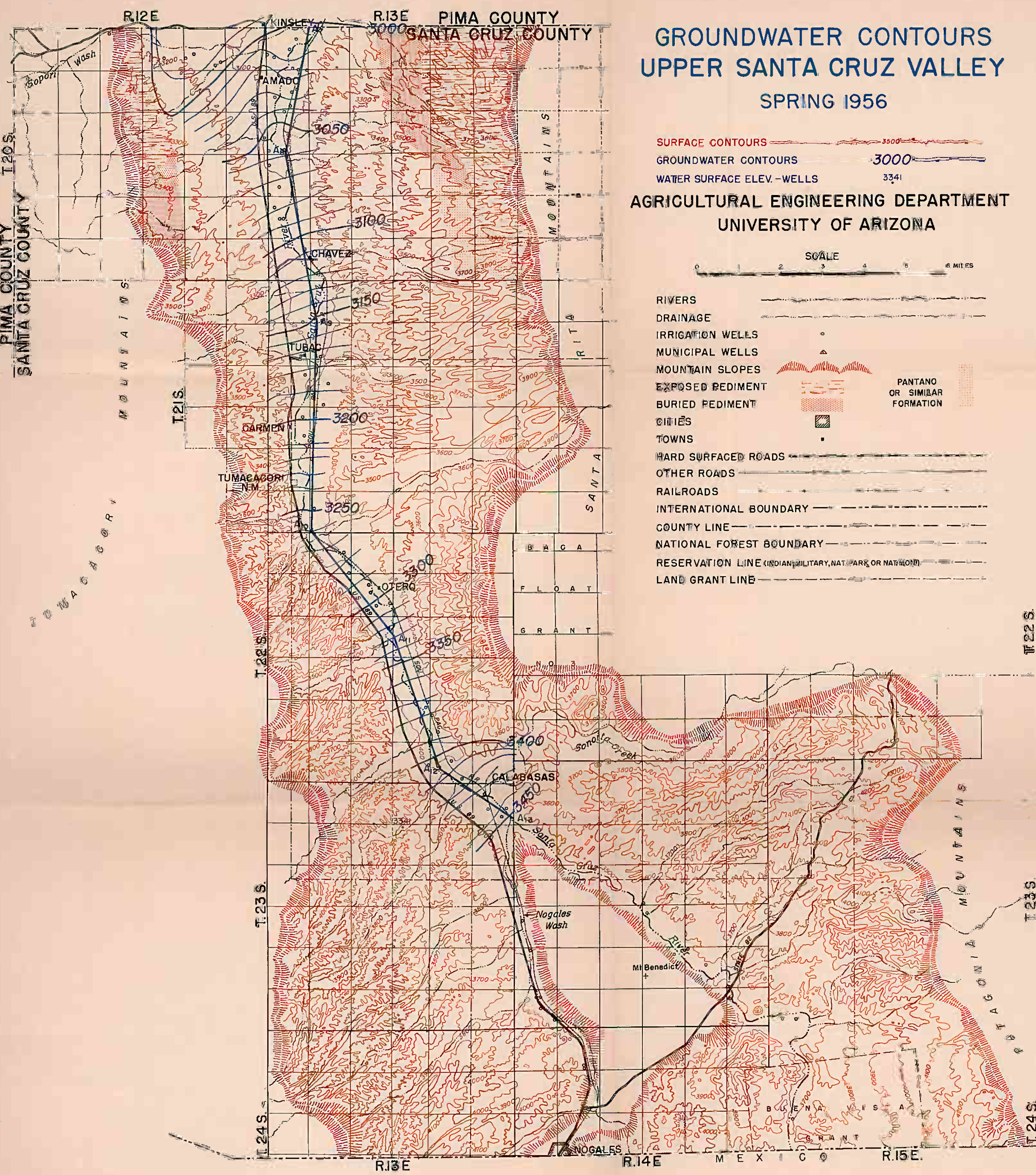
PLATE III



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UNIVERSITY OF ARIZONA
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DRAINAGE
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MOUNTAIN SLOPES
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TOWNS
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CARMEN
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OTERO
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NOGALES
Nogales Wash
Sonoita Creek
Santa Cruz River
Mt Benedict
Sopori Wash
SANTA RITA MOUNTAINS
TUMACACORI MOUNTAINS
PATAGONIA MOUNTAINS
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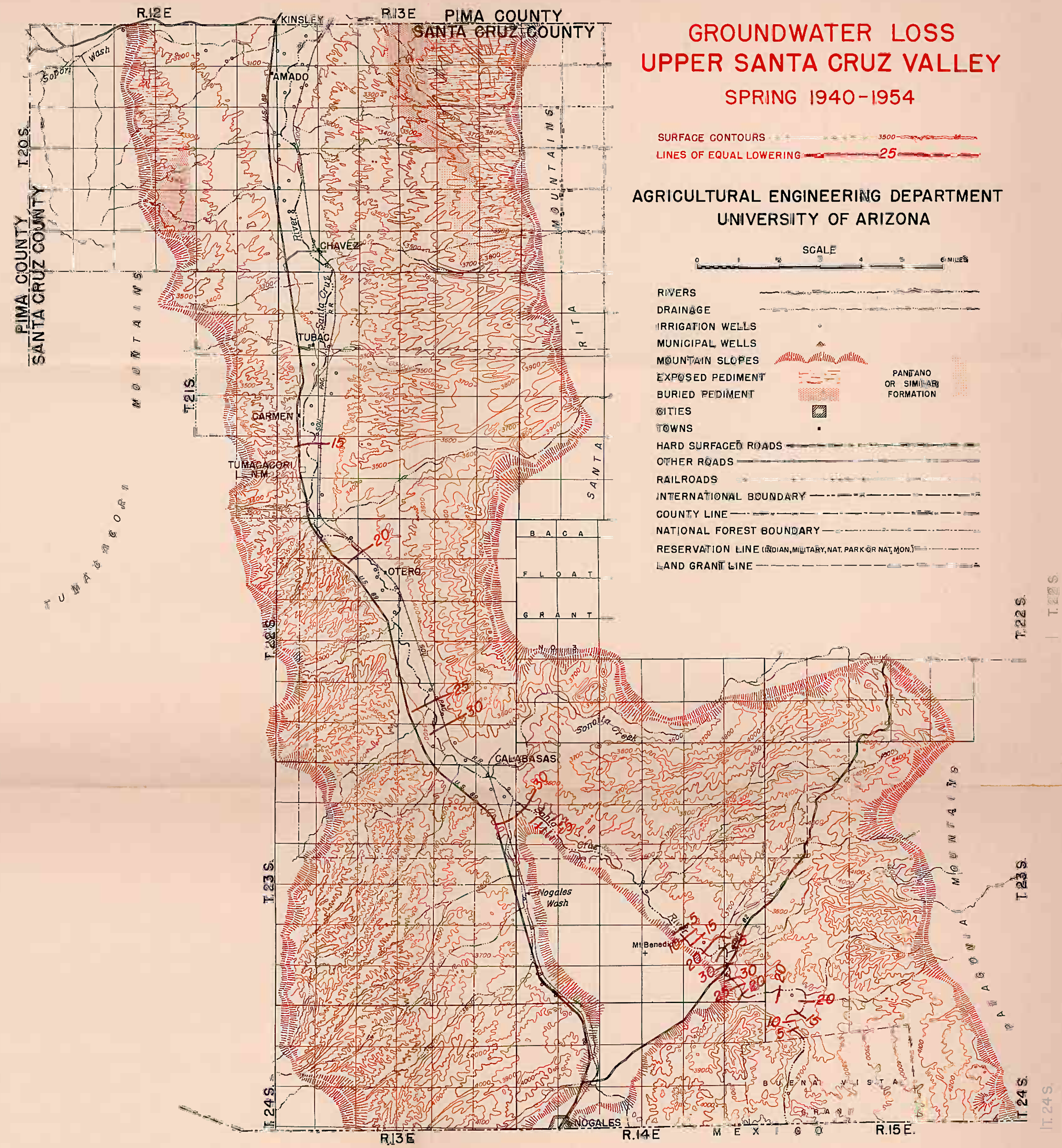
PLATE IV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PANTANO OR SIMILAR FORMATION
CITIES
TOWNS
HARD SURFACED ROADS
OTHER ROADS
RAILROADS
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CHAVEZ
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OTERO
CALABASAS
NOGALES
Mt.Benedict
Sopori Wash
Santa Cruz River
Sonoita Creek
Nogales Wash
TUMACACORI MOUNTAINS
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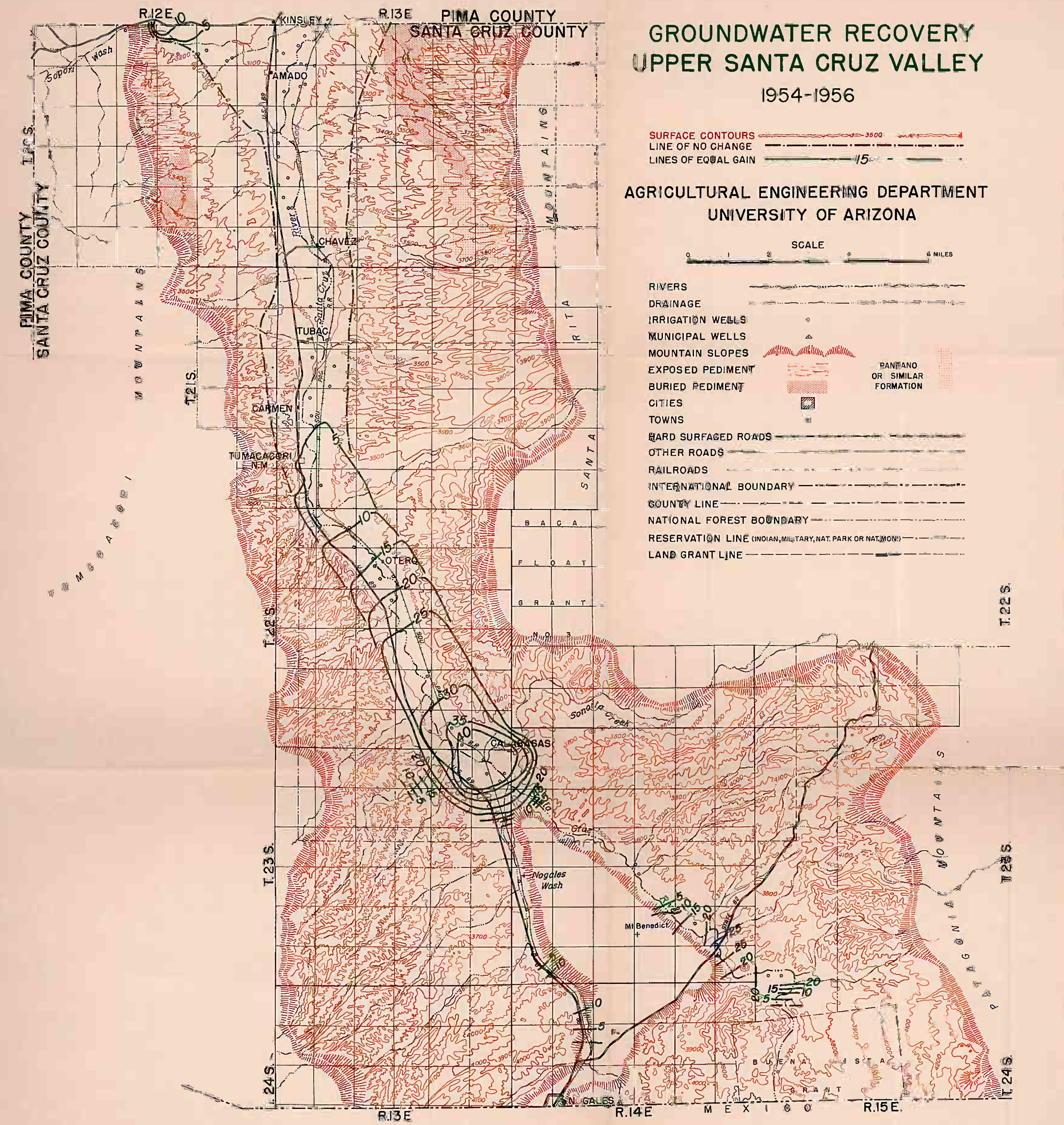
MEXICO
U.S. 89

PLATE V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DRAINAGE
IRRIGATION WELLS
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PANTANO OR SIMILAR FORMATION
CITIES
TOWNS
HARD SURFACED ROADS
OTHER ROADS
RAILROADS
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COUNTY LINE
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AMADO
CHAVEZ
TUBAC
CARMEN
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Santa Cruz River
Sonoita Creek
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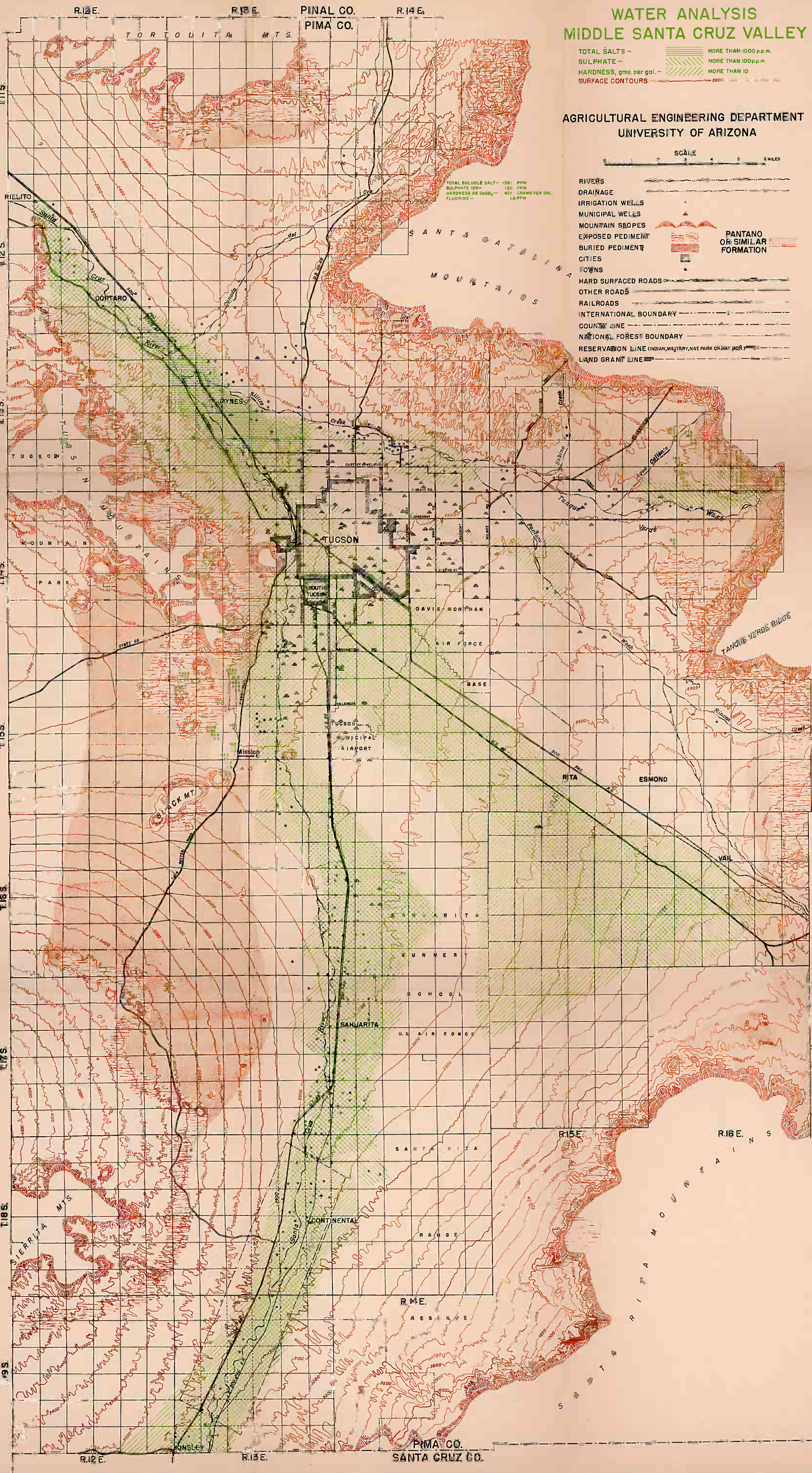
PLATE VII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SULPHATE – MORE THAN 100 p.p.m.
HARDNESS, gms. per gal. – MORE THAN 10
SURFACE CONTOURS 3000
AGRICULTURAL ENGINEERING DEPARTMENT
UNIVERSITY OF ARIZONA
SCALE
6 MILES
RIVERS
DRAINAGE
IRRIGATION WELLS
MUNICIPAL WELLS
MOUNTAIN SLOPES
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CITIES
TOWNS
HARD SURFACED ROADS
OTHER ROADS
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SAHUARITA
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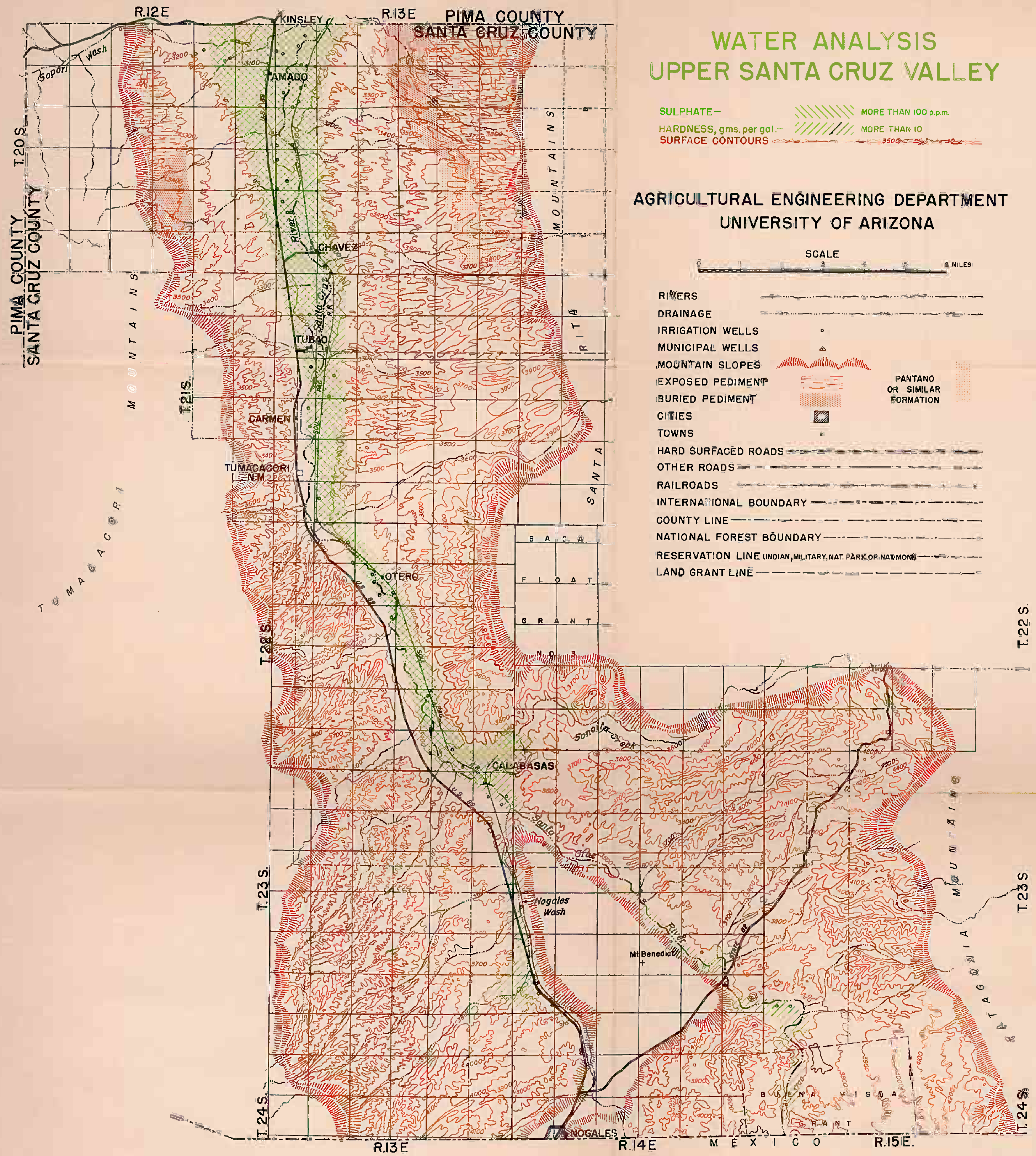
PLATE VIII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MORE THAN 100 p.p.m.
HARDNESS, gms. per gal.–
MORE THAN 10
SURFACE CONTOURS
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UNIVERSITY OF ARIZONA
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DRAINAGE
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CITIES
TOWNS
HARD SURFACED ROADS
OTHER ROADS
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T.24 S.
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SANTA RITA MOUNTAINS
TUMACACORI MOUNTAINS
PATAGONIA MOUNTAINS
BACA FLOAT GRANT NO. 3
BUENA VISTA GRANT
MEXICO
U.S. 89